XXVI. ASBESTOS TEXTILES

A. Product Description

Asbestos textiles are produced by standard textile production techniques involving carding, combing, and spinning of the asbestos fibers. Asbestos fibers can be blended with other types of fibers to give the resulting textile products added tensile strength. The manner in which asbestos fibers are processed into asbestos yarn and cloth products is illustrated in Figure 1.

There are two basic processes employed in asbestos textile manufacturing: the conventional and wet processes. Although most textiles are manufactured by the conventional process, each of these methods will be described.

1. Conventional Processing of Asbestos Fibers to Form Textile Products

In the conventional process, raw asbestos fibers of various grades are blended and mixed according to the fiber characteristics, manufacturing and finished product requirements, and intended use. The different grades of asbestos fiber received are placed in the fiber blender where they are mixed according to the requirements specified for the finished product. The selected fibers are then fed into a hopper where they are blended. Finally, the blended material is sent to the carding operation.

In the carding operation, asbestos fibers are combed into a relatively parallel arrangement called a fiber mat. This mat is pressed and layered into a lap consisting of alternating perpendicular arrangements of fiber mats. The lap is then slit into thin, continuous ribbons called roving. Cotton, rayon or other material may be added at this stage to strengthen the roving.

Roving, which has been mechanically twisted and spun to give it greater tensile strength, forms a single yarn. This yarn may be twisted with other single yarns, wire or other material to produce plied yarn that can be coated to produce thread or treated yarns. Plied yarns may be woven to produce

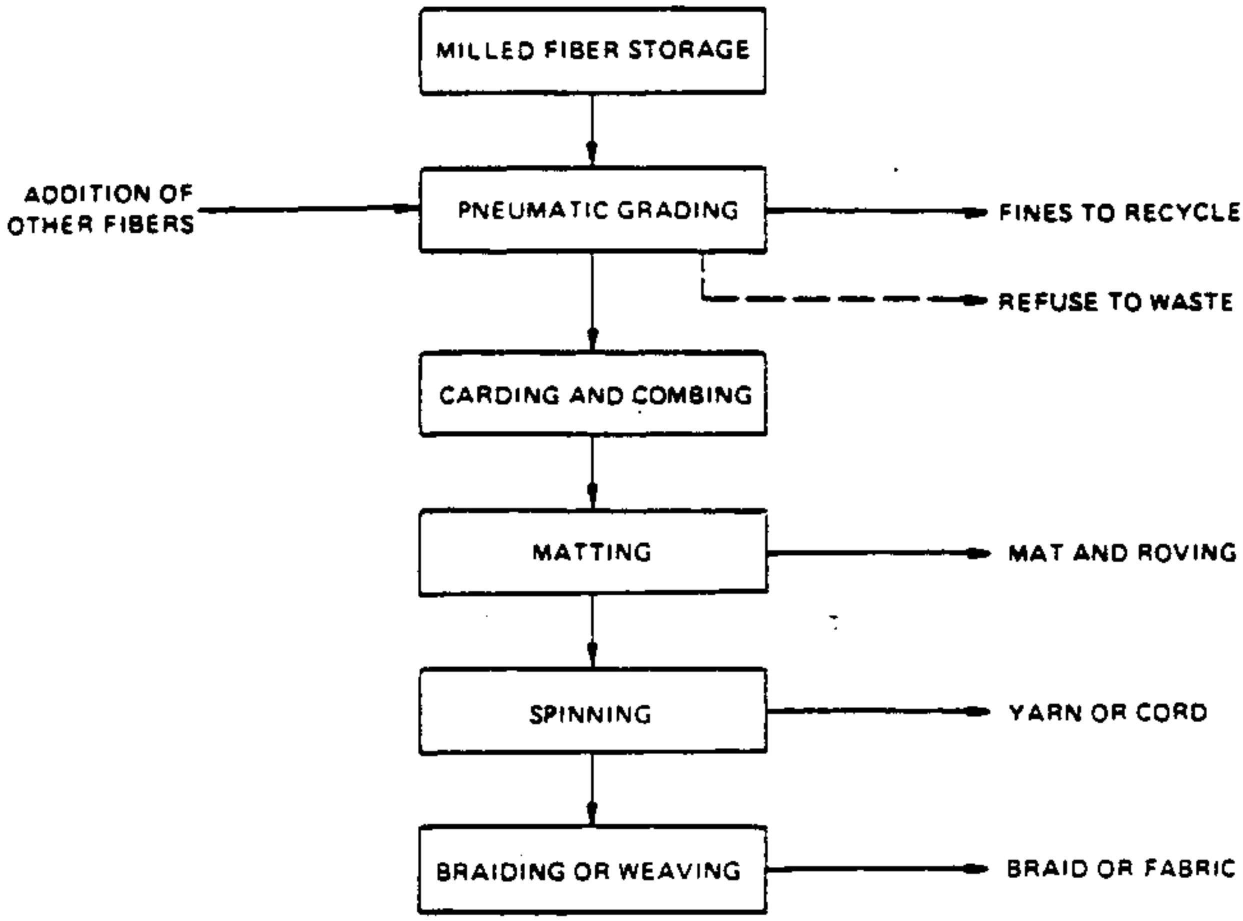

Figure 1. Manufacturing steps for asbestos textiles.

Source: NTIS 1975.

fabric, tubing (sleeving), or tape, as seen in Figure 2. Alternately, plied yarns may be twisted to form wicking and twisted rope, or braided to form braided rope or sleeving.

The conventional process of asbestos yarn manufacture can either be a dry or a damp method. These two methods are identical except that during the damp method the yarn is moistened either by contact with water on a roller or by a mist spray. This moistening of the yarns reduces the amount of fiber that becomes airborne and also aids the processing of fibers into yarn.

2. Wet Processing of Asbestos Fibers to Form Textile Products

The wet process is based on forming single filament fibers by extrusion. The process consists of making a gelatinous mixture of fine asbestos fibers in water with a volatile dispersant. The mass is then extruded through small dies to form asbestos thread. The extruded thread is spun to form yarn which is fabricated into various plied yarn products as in the conventional process.

The textile products formed using this wet technique tend to hold asbestos fibers better than those produced by the conventional processes, thus reducing workplace fiber levels, but the yarn formed has the disadvantage of poor absorption and impregnation characteristics.

3. Asbestos Textile Subcategories

There are eight main subcategories of asbestos textiles that are used in the various applications covered within this section. Each textile subcategory can be grouped into one of the two main categories, asbestos yarn or cloth, as follows:

- asbestos yarn;
  - yarn;
  - thread;
  - wick;
  - cord;
  - braided and twisted rope; and
  - braided tubing (sleeving).

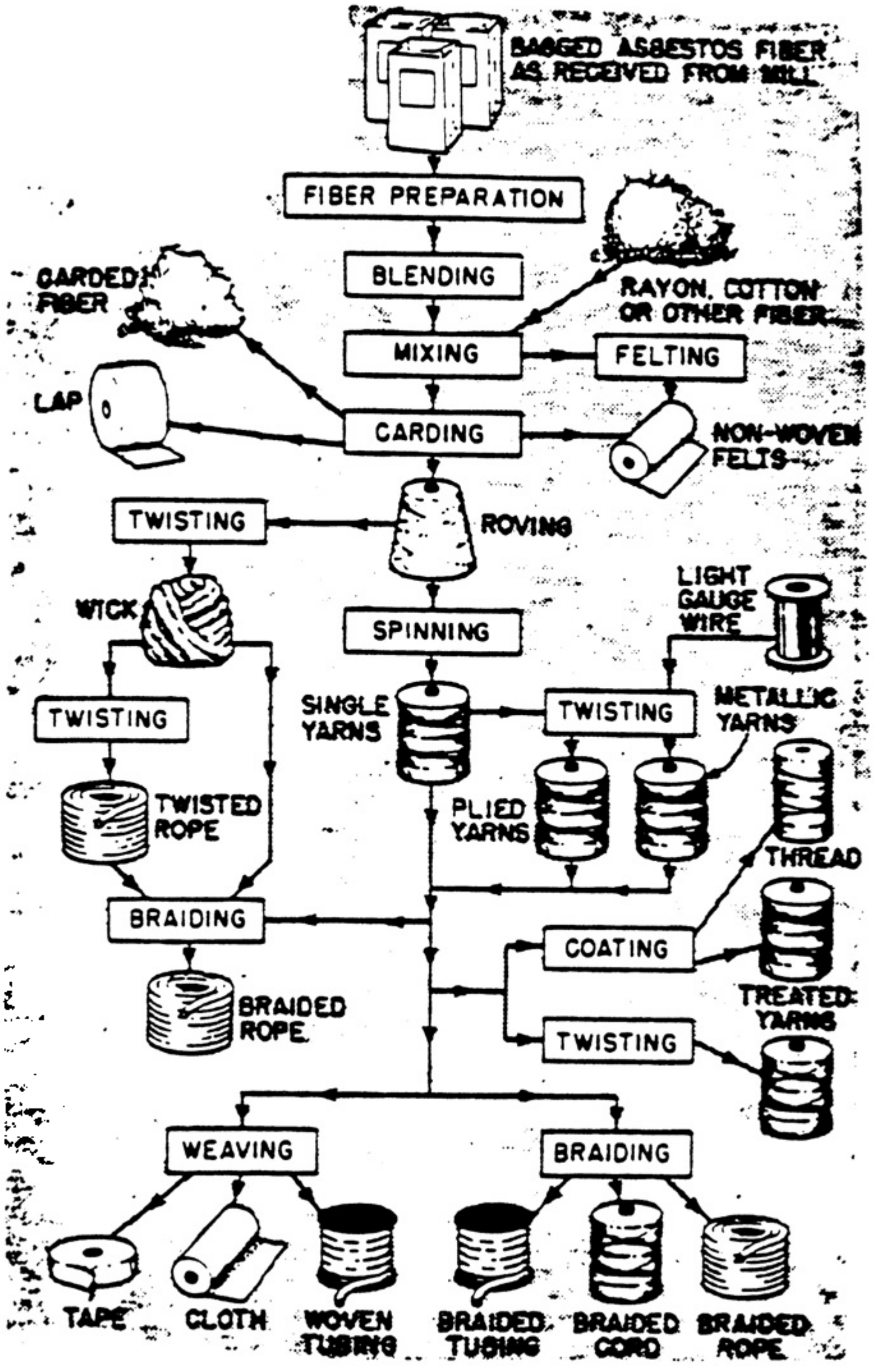

Figure 2. Manufacturing operations for asbestos textiles.

Source: Handbook of Asbestos Textiles. American Textile Institute. 1967.

- asbestos cloth
  - -- cloth;
  - -- slit and woven tape; and
  - -- woven asbestos tubing (sleeving).

The manufacturing process for each of these textile subcategories is briefly described, and some of the typical dimensions of the products are included. In addition, some of the typical fillers, carrier yarns, and inserts that are used in conjunction with asbestos containing materials are described (American Textile Institute 1967).

- Asbestos yarns are commonly reinforced with nylon, cotton, polyester, or wire. The asbestos yarns produced are made in various sizes and plies and serve as the basic components in the fabrication of many other asbestos textiles: twisted, woven, and braided. The amount of asbestos contained in asbestos yarns is the basis for designating asbestos textile grades as listed in Table 1. The American Society for Testing of Materials (ASTM) has designated various grades for asbestos textiles that differ slightly with each textile form.

- Asbestos threads are produced in both metallic (wire-inserted) and plain (non-metallic) classes. Depending on the tensile strength and thermal stability requirements, asbestos thread is furnished in different grades, although most of it is underwriters' grade (80-85 percent asbestos). Asbestos thread is often coated with an acrylic or wax coating to increase its strength and to facilitate the sewing of asbestos fabrics.

- Asbestos wick consists of several strands of asbestos yarn twisted together to form a general utility product with varied industrial applications (e.g., packing, or upon further processing the making of rope and braid).

- Asbestos cord is usually twisted asbestos yarn (a predetermined number of strands) that forms a cord of desired diameter and tensile strength. The yarns used may be sized or unsized, plain or wire-inserted, single or plied, depending on the end use of the product. Asbestos cord is manufactured in all standard ASTM grades and ranges in diameter from 0.06 inches to 0.38 inches.

- Asbestos rope is available in two styles: twisted and braided. Twisted asbestos rope is made by twisting two or more strands of asbestos wick tightly together. Heavier ropes contain a binder to hold the twist. Braided asbestos rope can be manufactured by three different processes: (1) by braiding one or more jackets of asbestos yarn over a

Table 1. Asbestos Textile Grades

Grades[a]	Asbestos Content by Weight
Commercial	75% up to but not including 80%
Underwriters'	80% up to but not including 85%
Grade A	85% up to but not including 90%
Grade AA	90% up to but not including 95%
Grade AAA	95% up to but not including 99%
Grade AAAA	99% up to and including 100%

[a]Asbestos textile grades differ with each asbestos textile form.

Source: Handbook of Asbestos Textiles. American Textile Institute. 1967.

core of asbestos rope or wick; (2) by braiding asbestos yarn braid over asbestos braid; and (3) by plaiting asbestos yarn into a square cross section (square braid). Asbestos rope is available in all ASTM grades and varies in diameter from 0.25 to 2.0 inches.

- Asbestos tubing (sleeving) can be made from asbestos yarns by braiding. Braided tubings are manufactured in all of the ASTM grades and range from 0.02 inches to several inches inner diameter (i.d.). The wall thickness varies from 0.03 inches to approximately 0.13 inches.

- Asbestos cloth is woven from various plied, twisted, and metallic yarns. There are five classes of asbestos yarns that can be used to produce asbestos cloth. The different classes of asbestos cloth are:

  -- Class A -- Cloth constructed of asbestos yarns containing no reinforcing strands.

  -- Class B -- Cloth constructed of asbestos yarns containing wire reinforcing strands.

  -- Class C -- Cloth constructed of asbestos yarns containing organic reinforcing strands.

  -- Class D -- Cloth constructed of asbestos yarns containing non-metallic inorganic reinforcing strands.

  -- Class E -- Cloth constructed of two or more of the yarns used in cloth classes A through D.

  The most widely used asbestos fabrics are woven from Class A (non-metallic) and Class B (wire-inserted) yarns.

- Asbestos tape is manufactured mostly as plain or non-metallic tape in all of the standard ASTM grades. It is a narrow woven fabric manufactured from plied yarn containing selvage edges (finished to prevent raveling). Additionally, tape may be slit from cloth (slit tape). Depending upon the application, the type of tape and the associated manufacturing process varies. For tapes requiring heat reflectivity, aluminum layers may be sprayed on or bonded to the cloth by a thermosetting resin. The thicknesses of plain tape range from 0.01 inches to 0.03 inches. Metallic tapes can be 0.06 inches and thicker. Standard widths of asbestos tape range from 0.5 inches to 6.0 inches.

- Asbestos tubing (sleeving) can also be made in a woven form. Asbestos yarns can be woven to form a tubing that has a significantly greater inner diameter than the braided tubings. Woven tubings are manufactured in all of the ASTM grades in diameters of less than one inch up to 24 inches.

Two additional asbestos textile subcategories are non-woven products that have been used for electrical insulation purposes, but do not fall into the two designated textile categories. Although these products were not produced by any companies identified during the analysis, brief descriptions are included:

- Asbestos roving is simply non-twisted strands of asbestos fibers that have been carded. Roving can be twisted to form wick or spun to form yarn. Asbestos roving is blended with cotton or other organic fibers to meet specific end-user requirements. It is supplied in the five standard ASTM grades. Asbestos roving has been used as electrical insulation, but no current applications could be found.
- Asbestos lap consists of parallel arrangements of asbestos fibers that have been combed and blended with organic fibers. Asbestos lap is a non-woven fabric and has been used in electrical insulation. No current uses of asbestos lap have been identified.

4. Current Application Areas for Asbestos Textiles

Historically, asbestos textiles have been used in a wide range of products, but many of the traditional products are no longer in production. Substitute fibers have taken up the bulk of the market for electrical and thermal insulation, fire resistant materials, and protective clothing.

The products that continue to be made in significant quantities using asbestos textiles are:[1]

- Woven friction materials;
- Packings and gaskets; and
- Specialty products.

Woven friction materials account for the majority of the asbestos textile products made from asbestos yarn and include woven brake blocks and clutch

[1] It should be noted that products made from asbestos textiles are different than similar products made from non-woven asbestos fibers. Woven friction materials and packings/gaskets made from asbestos textiles are not included in the non-woven asbestos product categories, but rather are included in the asbestos textiles category. A careful review of the processors data has been performed in order to ensure that no duplication of information has occurred.

facings. Typically, these woven products have better performance characteristics than molded products and are used in large industrial equipment such as oil well drilling rigs and cranes.

The two largest processors of asbestos textile materials are Standco Industries and Raymark Corporation. These companies are producers of woven friction materials and account for almost 90 percent of the asbestos textile market, although the trend in woven friction materials is away from asbestos containing materials in original equipment markets (OEM). In 1985, 50 percent of all OEM vehicular friction materials were expected to be asbestos free (Scott 1984).

Packings and gaskets made from asbestos textiles[2] include both yarn and cloth products. Asbestos yarn products, braid and rope, are used extensively in pump and valve packings and as seals for oven doors, boilers, and furnaces. Asbestos cloth is used to manufacture manhole and flange gaskets as well as seals in incinerator (hot-air) piping, nuclear power plant cooling water towers, and distillation columns.

Although some gasket and packing products continue to be made from asbestos textile materials, the general trend is to move away from asbestos containing products (Garlock 1986, Darco Southern 1986). Most gasket and packing manufacturers have stated that they will be completely out of the asbestos market by 1990 because of the availability of good substitutes.

Finally, specialty products continue to be made from asbestos textile materials, both asbestos cloth and asbestos yarn. It is often difficult to find substitute materials for these specialized applications, but products of this type are usually produced in relatively small volumes (less than 5,000

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[2] The majority of companies involved in the production of asbestos textiles are gasket and packing manufacturers, although they do not account for a very large proportion of the asbestos textile market (11 percent).

pounds). Some products made from asbestos textiles that fall into this category are:

- Mantles for gas lanterns (yarn);
- Wicks for catalytic heaters (yarn);
- Rotor vanes and impellar blades for pumps and compressors used in air tools (cloth);
- Ring type seals for valve and compressor plates (yarn); and
- Bearings for high temperature applications requiring water lubrication (cloth).

It is more difficult to find substitute materials for some applications of asbestos textiles that may require several of the favorable characteristics that asbestos can impart to textile products. For these types of applications, substitute materials may necessitate the use of a mixture of substitute fibers to impart all of the required characteristics to the substitute material. Companies that produce specialty products from asbestos are actively looking for substitute materials if none exist at present.

B. Producers and Importers of Asbestos Textiles

Asbestos textiles account for less than one percent of the total amount of asbestos fibers consumed for end-use products in the United States. In 1985, domestic consumption of asbestos fiber in the form of asbestos textiles was estimated to be approximately 919 tons (ICF 1986a). The majority of this fiber was Grade 3 chrysotile fiber. This figure is 16 percent of the 5,800 tons of fiber consumed in 1981 (ICF 1984a) in this category.

The quantity of asbestos fiber contained in asbestos textile products varies significantly, but an average figure of between 70 and 80 percent is a reasonable estimate of the asbestos content (Garlock 1986) for most asbestos textiles. The total amount of asbestos-containing textiles targeted for consumption in the U.S. is, therefore, estimated to be 1,690 tons of end-use textile products for 1985 (ICF 1986a).

Asbestos textile products consumed in the United States come from two sources: domestic processing of asbestos fibers into yarn and cloth and imports of yarn and cloth. Table 2 compares the imports of asbestos textiles and the domestic output of asbestos textile products for 1981 and 1985. Consumption and output have decreased by over 70 percent for both textile segments over the time period 1981 to 1985 (ICF 1986a).

The two processors involved in the manufacture of asbestos textiles for woven friction materials have stated that their products contain about 50 percent asbestos by weight. The amount of fiber consumed by these companies is estimated to be less than 800 tons.

As other asbestos yarn products are approximately 70 percent asbestos,[3] the remaining products can be estimated to contain less than 100 tons of asbestos fiber. An estimate of less than 900 tons of asbestos fiber consumed in the production of asbestos yarn products for companies that reported using asbestos in 1985 can therefore be made. Although no data for the asbestos content of specific asbestos cloth products were available, an estimate of 80 percent (Garlock 1986) asbestos content has been used to calculate the asbestos fiber consumption for asbestos cloth textiles. It is estimated that the companies that produced asbestos cloth products in 1985 consumed less than 200 tons of fiber. The total amount of fiber consumed in the production of all asbestos textiles in 1985 is therefore less than 1300 tons for 1985.[4]

The discrepancy between the asbestos fiber consumption estimated in Table 2 and the figure presented by the Bureau of Mines (1,344 tons) (Virta 1986) can partially be explained by incomplete reporting or identification of

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[3] The amount of fiber consumed in the production of asbestos textiles other than woven friction materials can only be estimated because the secondary processors were not willing to release or did not know the asbestos concentration figures for their products.

[4] Includes estimated fiber consumption of imported products.

Table 2. Asbestos Fiber Consumption for Textile Products and Output of Textile Products for 1981 and 1985

	Domestic Fiber Consumption[c] (tons)	Total Fiber Consumption[d] (tons)	Domestic Production of Textile Products (tons)	Imports of Textile Products (tons)
<u>Asbestos Yarn</u>				
1981[a]	3,920	5,040	5,600	1,600
1985[b]	558	823	1,125	455
<u>Asbestos Cloth</u>				
1981[a]	440	760	550	400
1985[b]	0	96	0	120
<u>Total</u>				
1981[a]	4,360	5,800	6,150	2,000
1985[b]	558	919	1,125	575

NOTE: The table identifies production only for those companies for which data have been collected during the survey. Some companies, especially those that import small quantities from small countries, may not have been identified.

[a]TSCA 1982.

[b]ICF 1986a.

[c]This calculation is based on confidential business information.

[d]Estimated total fiber consumption figures for 1981 are calculated using average asbestos concentration figures: Asbestos yarn is approximately 70 percent asbestos and asbestos cloth is approximately 80 percent asbestos.

companies processing asbestos textiles. The asbestos textile imports that have been accounted for totalled about 600 tons in 1985. The U.S. Imports for Consumption Schedule FT 246, published by the U.S. Department of Commerce (DOC 1985), however, indicates that approximately 1,100 tons of asbestos yarn, slivers, etc. (TSUSA 518.2100) were imported from 17 countries.[5]

Most of the secondary processors of asbestos yarn and cloth receive their materials from foreign companies and process the imported textile mixtures into end-use products. Several companies, however, receive textile mixtures from domestic sources. At least one company, Amatex Corporation, imports asbestos textile mixtures from plants in Mexico. Amatex does not do any secondary processing of these mixtures, but distributes them to other companies that are secondary processors (Amatex 1986).

There are other companies that have similar import/distribution practices (A.W. Chesterton 1986), and this may help to account for the discrepancy between imports identified in the survey and those reported by the Department of Commerce. Some companies are neither primary nor secondary processors, but rather importers and distributors. Data on these companies were not available for the initial 1982 EPA survey (ICF 1984b).

Some of the companies identified in the survey are involved in the processing of both asbestos cloth and yarn into end-products. In addition, the materials used by these companies are sometimes from several sources. Of the companies that have been identified, five are secondary processors of both

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[5] The TSUSA commodity code for yarn and related materials probably includes some products that are not considered textiles or are already finished products not requiring any processing, but the higher figure tends to indicate that information is missing regarding textile products imported from some countries. None of the companies that were contacted during the course of the survey indicated that any asbestos textiles were imported from any countries other than Canada, Mexico, and South Korea (Aztec 1986). Although these three countries account for the bulk of U.S. asbestos imports, other countries are exporting asbestos textiles to the U.S.

asbestos cloth and asbestos yarn. Tables 3 and 4 present quantities of yarn and cloth consumed and imported in secondary processing.

C. Trends

Thirteen companies involved in the production and distribution of asbestos textiles in 1985 have been identified. These 13 companies can be grouped into four categories based on their particular involvement in the asbestos textile market. The categories and the companies that fall under them are listed in Table 5.

In 1981, there were 21 processors of asbestos textiles (four primary, 17 secondary) as identified in the 1982 TSCA Section 8(a) survey. By 1985 the number of processors had dropped to six (one primary and five secondary). The change in processors identified in the survey is a 75 percent drop for primary processors[6] (from four in 1981 to one in 1985) and a 71 percent drop for secondary processors (from 17 in 1981 to five in 1985) (ICF 1986a, TSCA 1982).

In addition to processors identified in the survey, seven out of 16 companies (a 56 percent drop) identified as importers in 1982 (ICF 1984a) continued to import in 1985 (ICF 1986a).

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[6] The only domestic primary processor of asbestos textiles, Raymark Corporation, produces asbestos yarn from asbestos fiber at its plant in Marshville, North Carolina. Subsequently, the yarn is shipped to other Raymark plants where secondary processing to form woven brake blocks and clutch facings is performed (Raymark 1986). This production sequence is slightly different than that used by most manufacturers of woven friction materials. Most processors of these types of friction materials do primary and secondary processing at the same facility, and output is classified as woven friction materials. Raymark does not follow this pattern (the primary and secondary processing facilities are at different locations), so the output of the Marshville facility is classified as asbestos yarn. The yarn is then shipped to other Raymark facilities for secondary processing where it is fabricated into woven friction materials.

Table 3. Quantity of Asbestos Yarn Consumed by Secondary Processors

	Quantity of Domestic Asbestos Mixture Consumed[a] (short tons)	Quantity of Imported Asbestos Mixture Consumed (short tons)
Total	13.4	431.8

[a]The sources of domestic asbestos yarn are companies that import the mixture, but do not perform secondary processing. Only one company of this type could be identified importing 25 short tons of asbestos yarn for distribution to other companies that subsequently do the secondary processing.

Source: ICF 1986a.

Table 4. Quantity of Asbestos Cloth Consumed by Secondary Processors

	Quantity of Domestic Asbestos Mixture Consumed[a] (short tons)	Quantity of Imported Asbestos Mixture Consumed (short tons)
Total	9.4	94.8

[a]The sources of domestic asbestos cloth are companies that import the mixture, but do not perform secondary processing. Only one company of this type could be identified importing 25 short tons of asbestos cloth for distribution to other companies that subsequently do the secondary processing.

Source: ICF 1986a.

Table 5. Companies Involved in Asbestos Production and Distribution in 1985

Category	Company Name and Address	Asbestos Textile Product/Intended Use
Primary Processor of Asbestos Textiles from Asbestos Fibers	Raymark Corporation Marshville, NC	Asbestos yarn/woven brake blocks and clutch facings
Importer of Asbestos Textiles for Distribution Only	Amatex Corporation Norristown, PA	Asbestos yarn and cloth/distribution to domestic secondary processors
Secondary Processor of Asbestos Textiles Received Directly from Foreign Sources	A.W. Chesterton Woburn, MA	Asbestos yarn and cloth/packings and gaskets
	Arcy Manufacturing New York, NY	Asbestos cloth/welding blankets
	Aztec Industries N. Brookfield, MA	Asbestos cloth/gaskets
	The Coleman Company Wichita, KS	Asbestos yarn/mantles for gas lanterns
	Darco Southern Independence, VA	Asbestos cloth/gaskets
	Gatke Corporation Warsaw, IN	Asbestos cloth/high-temperature bearings
	Martin Merkel Houston, TX	Asbestos yarn/packings
	Standco Industries Houston, TX	Asbestos yarn/woven brake blocks and clutch facings
	Utex Industries Weimar, TX	Asbestos yarn/packings

Table 5 (Continued)

Category	Company Name and Address	Asbestos Textile Product/Intended Use
Secondary Processor of of Asbestos Textiles Received from Domestic Distributors	A.W. Chesterton Woburn, MA	Asbestos yarn/packings
	General Gasket Corp. St. Louis, MO	Asbestos yarn and cloth/ gaskets
	Rhopac, Inc. Skokie, IL	Asbestos yarn and cloth/ packings and gaskets
	Standco Industries Houston, TX	Asbestos cloth/gaskets
	Utex Industries, Inc. Weimar, TX	Asbestos cloth/packings

Source: ICF 1986a.

D. <u>Substitutes</u>

Asbestos has been used in textile products because it imparts desirable characteristics to the materials that are made from it. Asbestos based textile products have the following characteristics that make them ideally suited for use in high temperature and corrosive environments:

- Fire/acid resistance;
- Non-flammability;
- Low thermal conductivity; and
- Molten metal resistance.

Asbestos is also easily fabricated and exhibits great tensile strength and abrasion resistance. It is a flexible material in its fabricated form and is used for sealing applications especially when good compressibility and recovery are required.

Due to health concerns regarding asbestos inhalation, there has been a major effort to develop substitute materials that exhibit some of the characteristics of asbestos textiles. The major fibers used in the formulation of substitute textile products are:

- Fiber glass;
- Ceramics;
- Carbon/graphite;
- Aramids; and
- Polybenzimidazole (PBI).

In addition, some other fibers have been used to produce small amounts of textile materials that can be substituted for asbestos in some applications. Cotton and wool blends have been used in textile products as substitutes for asbestos, but in general they are not very resistant to heat. Quartz and other mineral fibers have also been used in small volumes. The five major substitute fibers mentioned above, however, account for the majority of the substitute materials that can replace asbestos.

Substitute textile products have already replaced asbestos to a certain extent and can be expected to replace most of the remaining segments of the market. An approximate breakdown of asbestos substitute markets and the percentage of the asbestos market that each has been able to assimilate is listed in Table 6.

1. Fiberglass Textiles

Fiberglass is used preferentially when looking for substitute products due to its good workability, durability, and cost (50-70 percent less than similar asbestos based textiles) (Darco Southern 1986). Other substitute materials tend to be more expensive than asbestos and typically are not used to the same extent as fiberglass (Utex 1986).

Fiberglass textile products have been widely used as substitutes for asbestos, but they do have several major shortcomings. For replacement products requiring abrasion or flux resistance, fiberglass alone is not an adequate substitute. Manufacturers have dealt with this problem by blending glass with other materials. For example, glass can be blended with aramids to produce textile materials that can withstand fairly high temperatures (500°F) and show good abrasion resistance (Chemical Business 1984).

Fiberglass fibers can be treated by chemical leaching with sulfuric acid to form a continuous-filament, amorphous silica product with the thermal performance of a refractory material. After treatment with acid, the resulting filament is almost pure silica (SiO_2) and can be woven to form textile materials with excellent thermal resistance. The temperature limit for ordinary fiberglass materials is around 1000°F, at which point they lose tensile strength and begin to melt. The amorphous silica products, however, retain their strength and flexibility to temperatures of 1800°F and will continue to provide thermal protection up to 3100°F, although some degree of shrinkage and embrittlement does occur as temperatures approach the upper limit (Armco 1979).

Table 6. Existing Market Shares for Asbestos Substitute Fibers

Substitute Fiber	Percentage of Asbestos Market
Glass	50%
Ceramic	15%
Aramid	15%
PBI	10%
Carbon	10%

Note: As more substitute products are becoming available, the market share for glass is beginning to dwindle.

Source: Garlock 1986.

Amorphous silica textiles have seen widespread use as thermal and electrical barriers and have replaced asbestos products to a great extent in these applications. The cost of high-temperature refractory silica textiles is not much greater than fiberglass textiles (Armco 1979) and only slightly greater than asbestos textiles used in similar applications. As the performance with regard to temperature limit is better than asbestos for the refractory glass products in nonabrasive applications (Amatex 1986a), substitution has taken place to a large degree.

In high temperature applications where compression and abrasion are likely to be encountered, other materials or blends of glass, silica, and other fibers are used. If only slight abrasion resistance is required, the refractory silicas do quite well. Rope gasketing for partial grooves in oven or furnace doors and sealing elements in all types of manufacturing equipment that handle heat (e.g., ovens, furnaces, boilers) can be made from refractory silicas.

Refractory silica textiles are not ideally suited for applications requiring a great deal of abrasion resistance, but their abrasion resistance capability can be augmented by specially treating the material with a hydrocarbon finish (Armco 1979). In general, however, refractory silica textiles are not used in areas where abrasive conditions would be encountered.

2. Ceramic Fiber Textiles

Ceramic fiber, consisting of high purity alumina and silica in various percentages, can be used to produce ceramic textile products. These ceramic textiles are similar to amorphous and textured silica products in that they exhibit refractory characteristics and can be used in high-temperature applications (up to 2300°F).

Fiberfrax yarn, a representative type of ceramic fiber yarn, contains approximately 20 percent organic fiber and is spun around corrosion resistant alloys of nickel and chromium (temperature limit 2000°F) or 1200°F monofilament glass strands. These inserts provide maximum tensile strength at elevated temperatures (Carborundum 1986).

Although ceramic fiber yarns have a high temperature limit in continuous use, the textiles made from them lose tensile strength after exposure to heat for extended periods of time. The temperature limit of the insert material must be considered in determining whether a ceramic fiber textile product can be used in applications where tensile strength is important.

In the application areas where substitution is incomplete, ceramic fiber textiles are viable substitutes for some applications currently using asbestos: furnace and oven door seals, flange and burner gaskets, and static packings. Ceramic fiber textile products have a higher temperature limit, are more flexible, conform to the shape required, and often have a longer service life than comparable asbestos based products. In general the costs of ceramic fiber products are comparable to asbestos products.

There are some drawbacks associated with the use of ceramic fiber for asbestos replacement cloth and yarn products. The ceramic cloth used in expansion joints, a gasket application, exhibits slightly more permeability at low temperatures and may be slightly more expensive (10-15 percent) in some product application areas (Carborundum 1986).

Ceramic rope products made from yarn are less dense than comparable asbestos products, are not as packable (too resilient), and therefore do not exhibit the required characteristics for some gasket applications. Ceramic fiber rope also exhibits poorer performance in some oven furnace door applications. Due to the low density and lower abrasion resistance of the ceramic products, they do not meet the standards of the traditional asbestos based products (Carborundum 1980).

Finally, static packings made from ceramic rope usually perform very well as asbestos replacement products, but there are not as many forms available, so complete substitution for all asbestos packings is not possible.

3. Aramid Fiber Textiles

Other substitute fibers that can replace asbestos in some textile applications are aramid fibers. By spinning a polymeric solution of aramids, a fiber can be produced that is a good replacement for asbestos. Aramid fiber is stronger on a by-weight basis than asbestos and can be used in pump packings, brake linings, and gaskets (DuPont 1980).

Aramids can also be blended with other fibers to produce asbestos replacement textiles that exhibit the favorable characteristics of each fiber type incorporated into the textile material. Amatex Corporation produces a heat-resistant textile that is made from Nomex and Kevlar fibers mixed with small amounts of polybenzimidazole (PBI) and glass fibers to raise the temperature limit of the material (Amatex 1986). The material, NOR-FAB , shows excellent abrasion- and heat-resisting characteristics, is lightweight, and is not susceptible to most acid and alkali solutions. By blending the aramid fibers with other synthetics and glass fibers, the favorable characteristics of aramids can be incorporated into products with higher temperature limits. In the case of NOR-FAB , excellent protection up to 650°F is possible with intermittent protection at much higher temperatures.

4. Carbon Fiber Textiles

Carbon fibers, another asbestos replacement fiber, are characterized by extremely high strength and high temperature resistance. Carbon fibers are made by controlled carbonization of an already formed fibrous structure based on an appropriate organic polymer. The organic polymers most commonly used in the production of carbon fibers are homopolymers of acrylonitrile and viscose rayon multifilament yarns.

The polyacrylonitrile (PAN) based fibers consist of 92-95 percent carbon (the rest being mostly nitrogen), and the higher strength rayon based fibers can be up to 99 percent carbon (Kirk-Othmer 1977). In general, the carbon fiber yarns and cloths are used in applications requiring strength and light weight (e.g., aerospace and industrial applications). Carbon fiber textiles often include other fibers, such as glass, along with a matrix resin (e.g., polyesters, epoxies, or polyimides).

Although there is some ambiguity regarding the term carbon fiber, it should be noted that this term does not include graphite fibers which are materials exhibiting the three-dimensional characteristic of polycrystalline graphite. Essentially all commercial carbon based textiles are made from carbon fibers (Kirk-Othmer 1977).

Carbon fibers have been used as an asbestos replacement in the production of friction materials. Even though the performance is superior to the asbestos goods that they replace, carbon fiber tends to be very expensive and availability can be a factor. In this and other substitution areas, the tradeoff between additional cost and improved performance must be evaluated. Some applications that require a specific level of performance may, therefore, use a more expensive fiber regardless of expense. In other application areas (e.g., aerospace), the cost of the fiber may be insignificant compared to the cost of the finished product in which the textile material is being used.

5. Polybenzimidazole Fiber Textiles

Polybenzimidazole (PBI) fibers can also be used to form asbestos replacement textiles. Based on the reaction of 3,3'-diaminobenzidine and diphenyl isophthalate, these aromatic polymers are prepared by conventional condensation techniques. The resulting polyimides can be fabricated into heat- and flame-resistant fibers that exhibit a unique property for synthetic polymers. Most synthetic polymers do not reabsorb moisture after being exposed to high temperatures. PBI, however, does regain moisture (up to 13 percent) and is therefore not as subject to degradation in some applications.

PBI fibers can be spun into yarns and then woven to form fabrics that are heat resistant up to 932°F. In addition, fabrics made from PBI fibers show good acid resistance, good cryogenic characteristics, and are readily processed on conventional textile equipment (Kirk-Othmer 1977).

Although PBI fibers exhibit excellent characteristics for very specialized applications (e.g., aerospace and other industries requiring high performance products), they tend to be very expensive. Most industries cannot afford to use PBI containing textiles in their asbestos replacement application areas because of the high cost and must either settle for other available substitute fibers or blend PBI fibers with other fibers to reduce the costs.

6. <u>Asbestos Replacement</u>

Typically, less expensive fibers such as fiberglass or ceramic are used to make up the bulk of any asbestos replacement textile, and the more expensive aramid, carbon, and PBI fibers are added to impart favorable properties on an application-by-application basis. For applications in which readily available substitute fiber textiles are available (i.e., commercially available single fiber products and relatively simple blends), the amount of fiber in the substitute product can be determined. In these application areas, however, substitution is considered to be complete.

The simple textile types (non-blended) are not considered to be replacements for the remaining asbestos textile applications as they do not meet the performance requirements for critical uses. For high performance application areas the amount of each fiber that is used in an asbestos replacement textile is determined by experimental procedure. By varying the concentrations of the available substitute fibers, a substitute textile product can be formulated that exhibits all of the required characteristics for a particular application.

The experimental nature of asbestos replacement procedures makes it difficult to speculate on the exact types of fibers that would be used in any given application area. Substitute products can be found for all asbestos textiles even though the exact nature of substitution is complicated. For example, the amount of fiber of a particular type and the weight of the finished product would be different than for a similar product made with asbestos.[7] In addition, actual formulations are often considered confidential and it is difficult to find data on product make-up.

As the level of detail needed to characterize specific replacement textile products is not readily available, some simplifying assumptions must be made for the asbestos textiles market. These assumptions are:

- All asbestos yarn and cloth products will be grouped into one product area (textiles);
- The blends of fibers in replacement textiles will be assumed to equal the market share for existing, asbestos replacement textiles that are made exclusively with one fiber (see Table 6);
- Service life will be assumed to be equal for all asbestos and replacement textiles (actual service life can vary for specific applications from one to 20 times that of asbestos, depending on the application);[8]

[7] As opposed to other products that use asbestos as an additive, asbestos textiles are comprised of up to 100 percent asbestos. Thus, formulations made with substitute fibers may vary significantly in weight from asbestos products. The relative density of the fiber compared to asbestos and the relative amount used as compared to asbestos determine the weight of the finished product made with substitute fibers.

[8] The actual service life is very dependent on the environment in which the asbestos-containing product and its substitute product would be contained. Depending on various conditions encountered in a particular use scenario (e.g., abrasiveness, high temperature) the possible substitute products would have greatly varying useful lives. Without performing an involved technical assessment of use conditions it is not possible to accurately predict the differences in the actual service life for the various substitute fiber-containing products relative to their asbestos counterparts.

- Unusual and unrepresentative products (e.g., aerospace replacement products that are 1,000 times as expensive as the asbestos product) will be excluded from the cost analysis.[9]

Attachment A contains a discussion of the calculations used in this analysis. The inputs for the Asbestos Regulatory Model for textile products are also presented.

E. Summary

Asbestos textiles can be grouped into two categories: asbestos cloth and asbestos yarn. A third category, asbestos protective clothing, has been eliminated because no producers could be identified.

Production and imports of these materials dwindled significantly between 1981 and 1985, and substitute products have taken over a large portion of the market. All segments of the asbestos textile industry for 1985 were down 70 percent or more compared to 1981 figures.

Substitution is complete for most product areas, but products are still made from asbestos in the following areas: woven friction materials, packings and gaskets, and specialty products. The major fibers that are used as substitutes are glass, ceramic, aramid, polybenzimidazole, and carbon fibers.

Analysis of the asbestos textile market and identification of substitute materials makes it possible to estimate the cost of substitute materials for remaining asbestos markets. The cost range for substitute products varies significantly depending on the application. Limited information makes it difficult to exactly constrain the costs, but average costs based on cost ranges established during the course of this analysis are presented in Table 7 (see Attachment A).

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[9] These products tend to be produced in very small volumes and data are generally not available concerning their cost and performance relative to asbestos products.

ATTACHMENT A

The relevant information used to calculate the costs of substitute textile materials relative to representative asbestos products is contained in this attachment.

As has been mentioned, for the application areas where substitution has taken place, the substitute textiles tend to use relatively simple blends of fibers. The remaining product areas are very diverse and replacement products differ significantly. If, however, essentially pure fiber products were made to replace the remaining asbestos textile markets, their costs would be in the ranges identified in Table 7.

Cost ranges are given because there are application-specific factors determining the actual cost of a substitute fiber textile. As the specifications of a particular application may include requirements regarding the quality as well as the quantity of substitute fiber that is used in the final product, the actual end-product costs will vary from application to application.

The cost of replacement for remaining asbestos products will be assumed to be the same for asbestos yarn and cloth products. An average textile product will, therefore, be the basis for determining the costs of substitution.

The average cost of an asbestos textile mixture that was being produced in 1985 was calculated to be $1.65/lb. (ICF 1986a). The equivalent prices for substitute products are given in Table 8.

Table 7. Costs of Substitute Fiber Textiles

Substitute Fiber	Cost Range of Fiber Relative to Asbestos for All Applications	Normalized[a] Weight of Fiber Used Relative to Asbestos	Cost Range of Finished Product Relative to Asbestos	Average Cost Relative to Asbestos
Glass	1-2	0.7	0.7-1.4	1.05
Ceramic	1-5	0.8	0.8-4.0	2.40
Aramid	6-9	0.8	4.8-7.2	6.00
Carbon	4-12	2.0	8.0-24.0	16.00
PBI	10-30	1.2	12.0-36.0	24.00

[a]Normalized with respect to amount used and weight of finished product.

Sources: Chemical Business 1984, Carborundum 1980, Industrial Minerals 1984, Spaulding 1986, Amatex 1986.

Table 8. Data Inputs for Asbestos Regulatory Cost Model for Textiles

Product	Output (tons)	Product Asbestos Coefficient (tons/ton)[a]	Consumption Production Ratio	Price ($/ton)	Useful Life	Equivalent Price ($/ton)	Market Share	Reference
Asbestos Mixtures	1,125	0.4960	1.511	3,300	1 year	3,300	N/A	ICF 1986a
Glass Fiber Mixtures	N/A	N/A	N/A	3,460	1 year	3,460	50%	Carborundum 1986
Ceramic Fiber Mixtures	N/A	N/A	N/A	7,920	1 year	7,920	15%	Chemical Business 1984
Aramid Fiber Mixtures	N/A	N/A	N/A	19,800	1 year	19,800	15%	Scott 1984
Carbon Fiber Mixtures	N/A	N/A	N/A	52,800	1 year	52,800	10%	Spaulding 1986
PBI Fiber Mixtures	N/A	N/A	N/A	79,200	1 year	79,200	10%	Garlock 1986

[a]Tons of fiber per ton of textile output.

N/A: Not Applicable.

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