

FILE NAME: Johns-Manville (JMA)

DATE: 1975 July

DOC#: JMA383

DOCUMENT DESCRIPTION: Report - US Asbestos - Utilization & Availability



ASBESTOS - UTILIZATION/AVAILABILITY

July 1975

Strategic Materials Management Information Program



Metals and Ceramics Information Center

Battelle
Columbus Laboratories
505 King Avenue
Columbus, Ohio 43201

used in yarns and textiles, medium-length fibers are used in papers, felts, asbestos-cement products, and in some filler uses, while shorts and "refuse" predominantly are used as fillers. The basic products may be used directly by other industries or such products may be incorporated into various end products. Companies making end items may or may not be integrated back to the mining and milling segment of the industry.

Asbestos Properties (2,4,16,21,22)

Asbestos fibers enjoy wide usage because of their strength, flexibility, thermal and electrical resistance, chemical resistance, and frictional properties. The natural fibrous structure of asbestos is considered as important to its use as its mineral composition. The fineness of chrysotile fiber in comparison with some other commonly encountered fibers is shown in the following tabulation:

COMPARISON OF DIAMETERS OF VARIOUS FIBERS
WITH ASBESTOS *

Type of Fiber	Fiber Diameter, inches	Fibrils in One Linear Inch
Human hair	0.00158	630
Ramie	0.000985	1,015
Wool	0.0008 to 0.0011	910 to 1,250
Cotton	0.0004	2,500
Rayon	0.0003	3,300
Nylon	0.0003	3,300
Glass	0.00026	3,810
Rock wool	0.000142 to 0.000284	3,520 to 7,040
Asbestos (chrysotile)	0.000000706 to 0.00000118	850,000 to 1,400,000

* Can. Mining and Met. Bull. (April, 1951).

Amphibole asbestos commonly runs to about twice the diameter of chrysotile but still is quite smaller in diameter than other common fibers.

The fibrous nature of asbestos imparts an extremely high surface area to the mineral and can be varied by adjustment of degree of fiber separation. Comparison of chrysotile asbestos with other fibrous materials in this regard is shown below.

COMPARISON OF THE SURFACE AREA OF VARIOUS FIBERS *

Type of Fiber	Surface Area by N ₂ Adsorption (Sq Cm per G)
Nylon	3,100
Acetate rayon	3,800
Cotton	7,200
Silk	7,600
Wool	9,600
Viscose rayon	9,800
Asbestos (chrysotile)	130,000 to 220,000

* Can. Mining and Met. Bull. (April, 1951).

The large surface area of "opened" asbestos contributes to its value as a filter material. The various materials may not only be used to filter some of the more inert materials (e.g., air, water, and oil) but, due to the relative chemical inactivity of the stable silicates, asbestoses can be used in corrosive media. The various asbestos mineral phases exhibit different reaction rates and stabilities in acidic and caustic reagents as shown in the following tabulation.

SOLUBILITY OF ASBESTOS *

Per Cent Loss in Weight, Refluxing Two Hours, 25% Acid or Caustic

	HCl	CH ₃ COOH	H ₃ PO ₄	H ₂ SO ₄	NaOH
Actinolite	20.31	12.28	20.19	20.38	9.25
Amosite	12.84	2.63	11.67	11.35	6.97
Anthophyllite	2.66	0.60	3.10	2.73	1.22
Chrysotile	55.09	23.42	55.18	55.75	0.99
Crocidolite	4.38	0.91	4.37	3.69	1.33
Tremolite	4.77	1.99	4.99	4.58	1.80

*Per Cent Loss in Weight, Room Temperature 26°C for 528 Hr,
25% Acid or Caustic*

	HCl	CH ₃ COOH	H ₃ PO ₄	H ₂ SO ₄	NaOH
Actinolite	22.55	12.14	20.10	20.60	9.43
Amosite	12.00	3.08	11.83	11.71	6.82
Anthophyllite	2.13	1.04	3.29	2.90	1.77
Chrysotile	56.00	24.04	56.45	56.00	1.03
Crocidolite	3.14	1.02	3.91	3.48	1.20
Tremolite	4.22	1.41	4.89	4.74	1.65

* Badollet, M. S., "Asbestos, A Mineral of Unparalleled Properties," *Can. Mining and Met. Ind.* (1951).

In addition to the desirability of large surface area for filtering purposes, this characteristic of asbestos also is important in the use of asbestos as a thermal and electrical insulating material. Coupled with this feature for asbestos in its use as a thermal barrier is a desirable emissivity characteristic. Comparisons of this asbestos property with the emissivities of other selected materials is shown below.

EMISSION OF DIFFERENT MATERIALS *

Material	Temperature, °F	Total Normal Emissivity
Aluminum, polished	100	0.03
Aluminum, foil	100	0.05
Chromium, polished	100	0.06
Gold, polished	100	0.02
Lead, polished	100	0.06
Platinum, polished	500	0.07
Silver, polished	100	0.02
Aluminum paint	100	0.27-0.69
Asbestos cloth	200	0.90
Asbestos paper	200	0.93
Glass, polished	100	0.90

* Shaw M. C., Asbestos Textile Institute, Phila., Penna. (April, 1951).

Asbestos (chrysotile) also has excellent electrical resistivity and dielectric strength which favors the material for its use in electrical insulation applications. However, the electrical insulating properties of chrysotile vary with its magnetite content--the more magnetite present, the more conductivity experienced. Three grades of asbestos have been established for various insulating purposes as described in the following tabulation and notes.

TYPE	MAXIMUM MAGNETIC RATING
II	0.75
IV	2.00
VI	4.00

Type II is intended for thin wall primary insulation--to .010".

Type IV is intended for moderately heavy wall primary insulation--to .045", or secondary insulation.

Type VI is used where the electrical properties are of minor importance--usually for secondary insulation.

The effect of the kind and amount of carrier fiber (cotton or rayon are commonly used) on the resistivity and dielectric strength of various asbestos textile grades used as electrical insulation is illustrated in the following tabulation for Type II (Magnetic Rating) asbestos.

	ASBESTOS CONTENT	VOLUME RESISTIVITY MILLIAMPS LEAKAGE			DIELECTRIC STRENGTH PER 500 MILS		
		0% RH	50% RH	75% RH	0% RH	50% RH	75% RH
CARDED FIBER							
Cotton Carrier Fiber							
UL	83.5	0.0	1.2	1.7	5.0	3.5	3.2
A	86.2	0.0	1.0	1.5	5.1	3.6	3.3
AA	92.3	0.0	0.9	1.4	5.0	4.4	4.2
AAA	96.6	0.0	0.8	1.2	5.9	5.4	4.6
AAAA	100.0	0.0	0.05	0.4	6.3	6.2	6.3
Rayon Carrier Fiber							
UL	83.9	0.1	1.8	2.0	4.1	3.4	3.0
A	89.3	0.1	1.7	1.9	5.1	3.5	3.3
AA	92.3	0.1	1.4	1.7	5.0	3.6	4.4
AAA	98.3	0.1	1.1	1.6	5.0	5.1	4.5
YARNS							
Cotton Carrier							
UL Grade Yarn							
Cotton Core	85.5	0.2	1.3	3.1	3.8	3.1	2.6
UL Grade Yarn							
Glass Core	80.8	0.0	0.5	1.3	6.8	3.8	3.5
AAA Grade Yarn							
Glass Core	97.1	0.0	0.0	0.0	12.0	6.9	6.3
AAA Grade Yarn							
Extruded	95.0	0.0	9.0	* 225--			2.4

*RH = Relative humidity.

**Not Burned Out.

Asbestos textile grades (Underwriters (UL), A, AA, etc.) have been established based on the weight percent asbestos in the material. Carrier fibers are added to improve processability and textile strength and do not markedly degrade the electrical characteristics of asbestos insulating materials in the quantities used.

The strength of asbestos fibers is quite good for chrysotile and crocidolite varieties but varies to low levels for tremolite and actinolite. The higher strength fibers compare favorably with the strength of metallic and nonmetallic fibers commonly encountered as shown below.

COMPARISON OF AVERAGE TENSILE STRENGTHS OF
VARIOUS MATERIALS *

Type of Material	Tensile Strength, Lb per Sq In
Ingot iron	45,000
Wrought iron	48,000
Carbon steel	155,000
"Nichrome" steel	243,000
Piano steel wire	300,000
Cotton fiber	73,000 to 89,000
Rock wool	60,000
Glass fiber	100,000 to 200,000
Chrysotile asbestos	80,000 to 200,000
Crocidolite asbestos	100,000 to 300,000
Amosite asbestos	16,000 to 90,000
Tremolite asbestos	1,000 to 8,000

* Can. Mining and Met. Bull. (1951)

The strength and stability of various asbestos phases is altered by elevated-temperature exposure as might be expected. Different mineral phases become unstable at different temperatures and their useful upper service temperature limitation is in part established by the degradation temperature. The effect of a 2-hour elevated-temperature exposure on the degradation of the common varieties of asbestos is indicated in the tabulation by abrupt deviations in the weight-loss date.

EFFECT OF TEMPERATURE ON LOSS IN WEIGHT
OF ASBESTOS FIBERS *

Temperature °F	Time	Loss in Weight				
		Amosite, %	Anthophyllite, %	Chrysotile, %	Crocidolite, %	Tremolite, %
400	2 hr	0.23	0.05	0.30	0.08	0.01
800	2 hr	0.98	0.38	2.17	0.73	0.22
1,000	2 hr	1.16	0.44	3.99	0.86	0.29
1,200	2 hr	1.39	0.54	12.75	1.04	0.37
1,400	2 hr	1.43	0.54	13.43	1.03	0.47
1,800	2 hr	1.53	2.39	13.77	0.77†	2.18

* Can. Mining and Met. Bull. (1951).

† Iron changing in weight caused by oxidation.

Combinations of the above and other properties establish the usefulness of asbestos minerals in a wide variety of applications. A physical properties comparison table which summarizes the characteristics of the six principal asbestos minerals is shown below. The processing techniques that have been developed to produce articles from asbestos also have been established based on combinations of properties. Knowledge of properties is quite a necessary prerequisite to the manufacture of asbestos products and the utility of any particular grade of asbestos is dictated by its fiber characteristics.

PHYSICAL PROPERTIES OF THE DIFFERENT VARIETIES
OF ASBESTOS

	<i>Chrysotile</i>	<i>Amosite</i>	<i>Antho- phyllite</i>	<i>Crocidolite</i>	<i>Tremolite</i>	<i>Actinolite</i>
Specified heat, B.Th.U./lb./°F.	0-286	0-183	0-210	0-201	0-212	0-217
Tensile strength, lb./sq. in.	80,000- 100,000	18,000- 90,000	4000 and less	100,000- 300,000	1000- 8000	1000 and less
Temp. at maxi- mum ignition loss	1800	1600- 1800	1800	1200	1800	—
Filtration properties	Slow	Fast	Medium	Fast	Medium	Medium
Electric charge	Pos.	Neg.	Neg.	Neg.	Neg.	Neg.
Fusion point, °F.	2770	2550	2675	2180	2400	2540
Spinnability	Very good	Fair	Poor	Fair	Poor	Poor
Resistance to acids and alkalis	Poor	Good	Very good	Good	Good	Fair
Magnetite content	0-5.2	0	0	3-0-5-9	0	—
Mineral impurities present	Iron, chrome, nickel, lime	Iron	Iron	Iron	Lime	Lime, iron
Flexibility	High	Good	Poor	Good	Poor	Poor
Resistance to heat	Good. Brittle at high temps.	Good. Brittle at high temps.	Very good	Poor Fuses	Fair to good	—
Ionizable salts. Micro-mhos (relative-elect. conductance)	1-82	1-84	0-58	0-84	—	—
Colour	Green, grey to white	Yellowish- brown	Yellow, brown to white	Blue	White	Greenish
Texture	Fine and silky	Harsh and coarse	Soft to friable	Rough, harsh but flexible	Harsh or friable	Harsh, brittle

U.S. Production (2,4,7,19-27)

Many of the major asbestos-products manufacturing companies have captive fiber sources which are either wholly or partially owned (U.S. and Canadian mines). Some of the more than 400 companies making asbestos products are (19-27):

Amatex Corporation
Norristown, Pennsylvania

Armstrong Cork Company
Lancaster, Pennsylvania

Atlas Textile Corporation
North Wales, Pennsylvania

A&M Insulating Company
Chicago, Illinois

The Bendix Corporation
Southfield, Michigan

The Celotex Corporation
Tampa, Florida

Cement Asbestos Products Company
Birmingham, Alabama

Certain-teed Products Corporation
Valley Forge, Pennsylvania

The Clark Asbestos Company
Cleveland, Ohio

Congoleum Industries, Incorporated
Kearny, New Jersey

The Flintkote Company
East Rutherford, New Jersey

The GAF Corporation
New York, New York

Garlock, Incorporated
Rochester, New York

Huyck Corporation
Rensselaer, New York

Johns-Manville Corporation
Denver, Colorado

Kentile Floors, Incorporated
Brooklyn, New York

National Gypsum Company
Buffalo, New York

Nicolet Industries, Incorporated
Ambler, Pennsylvania

Polyrez Company, Incorporated
Woodbury, New Jersey

H. K. Porter Company
Pittsburgh, Pennsylvania

Raybestos-Manhattan, Incorporated
Trumbull, Connecticut
N. Charleston, S. Carolina

Scandura, Incorporated
Charlotte, N. Carolina

Supradur Manufacturing Corporation
New York, New York

Union Carbide Corporation
Niagara Falls, New York

Uniroyal Incorporated
Winnsboro, South Carolina

Uvalde Rock Asphalt Company
San Antonio, Texas

Asbestos products may be grossly divided into two groups, woven and nonwoven types. In the former, asbestos fibers of suitable classification are worked into rovings, yarns and cords and hence can be woven, braided, or knitted into textile-like products. Spinning fiber mixtures composed of various asbestoses and fibers of numerous other materials, both of organic and inorganic origin (e.g., metallic) are prepared giving rise to several classes of asbestos textiles. Generally, nonasbestos fibers are incorporated in asbestos textiles to facilitate yarn, cord, and cloth type manufacturing as well as to impart specific properties and characteristics to the textile-like products. Nonwoven-type asbestos products use asbestos fibers in composites incorporating a wide variety of asbestos fiber classes with matrix bonding materials of several types. Asbestos-containing products of this type utilize the fiber content for insulating, frictional, filling, and strengthening purposes. Raw asbestos may be used in insulating, packing, wicking, and filtering applications. (2,4)

Asbestos in the raw condition from mills may be provided to the manufacturers in the crudy (essentially unopened), medium-opened, or well-opened conditions (see Figure 1). As might be expected, the various manufacturing processes require asbestos in various degrees of openness to permit manufacturing capability as well as to attain desired properties in products. The opening of asbestos "bundles" is achieved by mechanical comminution (basically beating) and is frequently aided by the chemical action of reagents added to fibrilize bundles and to cleanse fibers of impurities (e.g., entrained magnetite). "Washed" asbestos (i.e., to minimize impurities) has improved electrical insulating properties.

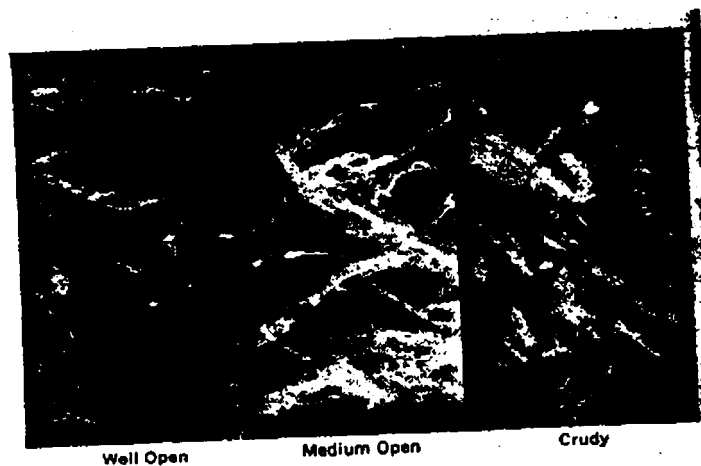


FIGURE 1. TYPICAL DEGREES OF ASBESTOS MINERAL OPENING

Textile-type products are manufactured in fundamentally the same way as other textiles with suitable modifications of technique and machinery to accommodate asbestos fiber characteristics. Asbestos papers and boards are prepared by mixing fibers with various bonding agents (e.g., starch, glue, water glass, plastics, cements), felting processes, pressing operations (commonly by rolling), and drying techniques. Composites are made by mixing fibers with the matrix materials and subsequently molding or spraying the composite to the form required by the application. Also composites are prepared by impregnating woven asbestos products with matrix materials (e.g., brake shoes and clutch plates).

While information was not obtained concerning the amounts of the various asbestos-containing products manufactured in the U.S., some order-of-magnitude data can be surmized by examination of consumption data.⁽⁷⁾ Accordingly, U.S. Bureau of Mines consumption data for BM I asbestos (spinning fiber classification), 19,300 short tons in 1973, would indicate about 2.2 percent of total 1973 asbestos consumption in products requiring woven products. Other sources indicate somewhat higher and lower quantities for textile type products, but generally all indications are that while textile-type products require some of the better grades of asbestos, quantities used are fairly small compared to total asbestos used.⁽²³⁾ The balance of asbestos products are in the form of felts (e.g. in paper and boards) and as fiber components in the various composite products (e.g. asbestos cement, floor tiles, and plastics). A very small amount of raw asbestos products is used directly (e.g., as insulation). The quantities of asbestos products manufactured in the various categories are indicated by the consumption data given in a subsequent section of the report. The variety of products manufactured is suggested by the application examples given in the following section.

Typical Applications^(2,4)

The number of end-use items bearing asbestos numbers above 3000 as previously mentioned. The uses are largely composite uses wherein asbestos is the fibrous component to impart strength, insulating properties, and other desirable characteristics such as frictional properties

with concomitant minimum wear and as extenders of more expensive matrix materials (e.g., plastic resins). Other reasons for asbestos use are suggested. Associated with both textile and nontextile-type products are applications wherein asbestos is useful because of its incombustibility. Examples of asbestos-bearing products in various categories are:

Textile type products:

Clothing:

Suits	Leggings
Helmets	Aprons
Gloves/Mittens	Boots

Blankets:

- Firestops (e.g. theater curtains)
- Lagging (thermal insulating)
- Welding barriers
- Filtering: fruit juice, acids, inks, dust (baghouses)
- Diaphragms (e.g. chlorine/caustic cells)
- Acoustic barriers

Tapes:

- Lagging (thermal insulating)
- Wicking
- Insulating (electrical applications)
- Belting (conveyor type)
- Fastening (e.g. laboratory equipment tie-ups)
- Packing

Ropes, yarn, threads
Same as for tapes

Board and paper products:

- Insulating applications(thermal)
 - Roofing
 - Pipe lagging, boiler lagging
 - Stove lining
 - Transportation (engine heat control)
 - Manufacturing (e.g., glass industry operations)
 - Cartridge wadding
- Insulating applications (electrical)
 - Motor windings
 - Appliance parts
 - Wire wrapping, cable wrapping
 - Electrolytic cell diaphragms
- Filtering
- Wicking
- Packing
- Gasketing

Asbestos cement products:

- Insulating (thermal barrier, firestops)
 - Sheathing
 - Partitions
 - Siding
 - Roofing
- Insulating (electrical)
 - Instrument paneling
 - Motor encasements
 - Conduits
 - Switch boards

- Containment (corrosion resistant)
 - Tanks and vats (corrosives, e.g., bleaches)
 - Pipes (e.g., water, sewage, gas, corrosives)
 - Hoods (thermal and corrosive resistant)
 - Frictional (e.g., elevator brake shoes)
- Asbestos composite products:
 - (Note: Asbestos textiles commonly are composites of asbestos and nonasbestos fibers.)
- Asbestos-plastic composites
 - Floor tiles
 - Sheet vinyl flooring
 - Aircraft and missile molded plastics
 - Lamp sockets
 - Switch parts
 - Resistance mountings
 - Wire insulation (electrical)
 - Corrosion resistant compositions (e.g., underground insulation)
 - Buttons
 - Sealants (e.g., percussion caps in large shells)
- Asbestos - other composites
 - Insulating sprays (thermal and acoustical barriers)
 - Asbestos cements
 - Asbestos paints
 - Gaskets
 - Clutch facings (asbestos textile-type composites as well as free-fiber composites are used)
 - Brake linings

While the above list is long, it does not begin to cover the multiplicity of applications for asbestos fibers. A more complete listing, although still a partial listing, is offered in Appendix C from Reference 4. Due to the wide variety of products and numerous manufacturers of products, there is not a convenient composite price for asbestos-containing items which would have meaning relative to the value of items purchased and used by any consumer segment. Prices paid for crude and milled asbestos, which have shown a steady rise in the 1973-1975 period, have undoubtedly influenced prices of end-items in proportion to asbestos content.

U.S. Consumption (DoD Usage) (6-9,23-27)

There are several sources issuing apparent U.S. asbestos consumption data and these sources use various categorical (product) breakdowns and show various quantities of asbestos used. For example, total apparent

U.S. 1973 asbestos (all types) consumption is variously listed as 832,000 short tons, 862,401 st, 876,147 st, and 885,000 st.^(6-9,23) Reports for apparent 1974 consumption vary between 845,800 and 874,000 short tons. Thus, the range and mean values for apparent U.S. asbestos consumption are

1973 832-885,000 st (864,000 st)

1974 846-874,000 st (860,000 st)

These data indicate only about a 0.5 percent decrease in asbestos usage in asbestos usage in 1974 compared with 1973 consumption but other sources state that the decrease was as much as 3 percent. Table 1 presents the U.S. Bureau of Mines breakdown of 1974 apparent U.S. consumption by end use, asbestos grade and type.⁽¹⁴⁾ Note that the categories differ somewhat from those used by other analysts whose data are given on pp 34 and 36. The variation in consumption data reported from different sources is related to the collection of incomplete data from various respondents to producer and marketing surveys. Also, a difficulty is experienced with determining the amounts of asbestos moving into and out of producer and manufacturer inventories (i.e., stocks), so that actual consumption for any particular time period is an approximation.

As mentioned, various analysts utilize somewhat different asbestos end-item categories for several reasons. An example of the category differences used is shown in the following tabulations.

<u>Asbestos Products</u>	<u>Percent of Total Consumption, 1973⁽²³⁾</u>
Asbestos cement pipe	17.0
Asbestos cement sheets, shingles, etc.	6.0
Asbestos latex sheet	16.0
Floor tile	15.0
Asbestos paper	10.0
Roof coatings	4.0
Joint cements	1.6
Asbestos/(in) plastics	2.1
Friction materials	6.0
Asbestos textile	2.0
Miscellaneous*	20.3

*Asphalt paving, caulking compound, sealants, packings, gaskets, sound deadeners, acoustical plaster, ceiling tile, automotive undercoatings, filters, oil-well drilling muds, etc.

TABLE 1. 1974 U.S. APPARENT CONSUMPTION OF ASBESTOS BY END USE CATEGORY, GRADE, AND TYPE⁽¹⁴⁾

End-Item Category	Chrysotile								Total Crocidolite	Amosite	Anthophyllite	Total Asbestos	Percent
	Grades 1 and 2	Grade 3	Grade 4	Grade 5	Grade 6	Grade 7	Grade 8	Total Chrysotile					
Asbestos Cement Pipe	-	-	926	203	-	723	-	1,852	364	11	2	2,229	26.4
Asbestos Cement Sheet	-	-	109	158	520	118	-	905	-	43	-	948	11.2
Flooring Products	-	-	-	490	-	1,045	-	1,535	-	-	-	1,535	18.1
Roofing Products	-	-	37	111	127	463	-	733	-	17	-	755	8.9
Packing and Caskets	1	19	75	75	14	103	-	287	1	-	-	288	3.4
Insulation, Thermal	-	1	9	1	34	28	-	73	-	18	-	91	1.1
Insulation, Electrical	-	-	4	16	-	27	-	47	-	-	-	47	0.6
Friction Products	-	56	13	295	63	366	3	796	-	-	2	798	9.4
Coating and Compounds	-	-	1	4	3	367	4	379	-	-	-	379	4.5
Plastics	4	10	9	8	-	75	63	169	2	-	7	178	2.1
Textiles	7	142	39	8	-	8	-	204	-	-	-	204	2.4
Paper	-	-	55	4	239	333	-	631	2	-	-	633	7.5
Other	-	3	11	-	23	327	-	364	4	5	-	373	4.4
Totals	12	231	1,288	1,373	1,023	3,983	70	7,980	373	94	11	8,458	100

<u>End Uses</u>	<u>Percent of Total Consumption Reported, 1973⁽⁷⁾</u>
Construction	29.89
Floor tile	19.94
Friction products	7.97
Paper	10.29
Asphalt felts	5.25
Packing and gaskets	2.51
Insulation	1.78
Textiles	1.28
Other	21.07

<u>Asbestos Products</u>	<u>Percent of Industry Distribution, 1972⁽⁷⁾</u>
Asbestos cement pipe and sheet	26.8
Vinyl asbestos floor tile	18.7
Sheet vinyl flooring	11.8
Roofing papers	10.1
Gaskets and packing	8.6
Friction materials	8.4
Insulation, pipe and thermal	6.2
Coatings and compounds	4.1
Plastics	2.8
Electrical insulation	1.2
Export (and re-export)	1.0
Miscellaneous	0.3

The difficulties in analyzing the asbestos consumption picture using the incomplete data from various sources are apparent. However, it is obvious that a large amount of asbestos is consumed by the construction industry and that small but important uses exist within such industries as the appliance manufacturing industry and other equipment manufacturers of various products. The transportation industry takes a fairly large amount of the total asbestos used in the form of insulating, packing, and gasket products, and friction materials for such as clutch and brakeshoe applications. Based on a very brief study of the available data and incorporating the categorical analyses of others, the following consumption pattern is suggested.

	<u>Range</u>	<u>Best Estimate</u>
Construction	55 to 65%	56%
Flooring	20 to 30%	22%
Transportation	10 to 15%	14%
Appliances	5 to 10%	6%
All other	3 to 7%	2%

The limited and incomplete nature of aspects of U.S. asbestos consumption patterns does not permit a good estimate for Department of Defense asbestos consumption. However, an attempt at estimating DoD asbestos consumption is given in the following.

The diversity of DoD activities is wide but it is believed that DoD is not engaged in construction activities to the same extent as the balance of the U.S. economy. Thus, it is not possible to assign a 6 percent share of the construction uses for asbestos to DoD. [The 6 percent value represents the DoD budget in terms of the U.S. FY 74-FY 75 Gross National Product (GNP).] Similarly, it is believed unjustified to assign a 6 percent share of flooring uses for asbestos to DoD. On the other hand, the use of asbestos in the U.S. is so diverse and diffuse that the portion of total asbestos used by DoD compared to total asbestos used by the U.S. is proportional to the DoD budget as a percent of the GNP (i.e., 6 percent) in the categories of Transportation, Appliances, and All Other. Thus, using quite arbitrary percentage assignments for DoD asbestos consumption in the Construction and Flooring categories and \$DoD/\$GNP ratio in the other categories, an estimate for total DoD asbestos usage may be made as follows.

1974 U.S. Asbestos Consumption

<u>Category</u>	<u>Best Estimate</u>	<u>DoD Share of Best Estimate</u>
Construction	56%, 481,600 short tons	3%, 14,448 short tons
Flooring	22%, 189,200 short tons	3%, 5,676 short tons
Transportation	14%, 120,400 short tons	6%, 7,224 short tons
Appliances	6%, 51,600 short tons	6%, 3,096 short tons
All other	2%, 17,200 short tons	6%, 1,032 short tons
Total	860,000 short tons	31,476 short tons

Accordingly, DoD asbestos consumption, i.e., the total asbestos content of products used by DoD, is estimated as 3.66 percent of total U.S. consumption (basis 1974). Estimates of DoD asbestos usage also should consider that very probably a large proportion of DoD consumption is in the more sophisticated grades of asbestos. Also, quite apart from direct DoD asbestos consumption, is the indirect DoD dependence on asbestos in the major roles of critical importance to DoD supporting industries. Undoubtedly, numerous

segments of the U.S. manufacturing industries would find it extremely difficult, if not impossible, to operate without asbestos products. Appendix C includes photographs of some direct DoD asbestos products and applications. (4)

Exports of Asbestos-Containing
Products from the United States (Imports)

Manufactured asbestos products exported from the United States in 1974 totaled more than 64,000 short tons with a valuation of greater than \$60 million. The kinds of products, their weight or number, and valuation as reported by U. S. Bureau of the Census were⁽²⁰⁾:

<u>Articles</u>	<u>Weight or Number</u>	<u>Valuation, \$</u>
Asbestos-cement products	87,241,503 lb	11,063,243
Gaskets	847,961 lb	1,684,712
Packing	5,622,108 lb	10,897,330
Insulation (thermal and acoustic)	--	4,541,471
Textiles and yarns	18,930,697 lb	8,407,609
Protective clothing	--	556,218
Cloth for automotive use	1,696,151 no.	1,856,440
Clutch facings and linings	733,386 no.	647,276
Brake linings automotive	8,420,952 lb	6,475,469
Other brake linings	3,427,859 lb	3,661,487
Manufactured products (other than friction)	--	10,467,063

Manufactured articles also were imported into the U.S. in 1974 in the amounts and evaluations shown below⁽²⁰⁾.

<u>Articles</u>	<u>Weight, lb</u>	<u>Valuation, \$</u>
Asbestos-cement products	59,125,920	7,626,521
Asbestos yarn, slivers, etc.	7,248,093	7,923,813
Other asbestos products	--	4,684,986
Total valuation		20,235,320

Scrap (2,28)

Virtually no recycling of asbestos fibers outside of mills and asbestos-product-manufacturing facilities has been attempted. In-house scrap can be reverted to penultimate processing during the manufacture of several kinds of

APPENDIX A

ASBESTOS ORE PROCESSING TO FIBERS^(2,5)

The major processes involved in the production of asbestos ores to fibers include mining, ore preparation, fiber release, fiber cleaning, and finally fiber grading, storage, and shipment. Open-pit mining is most commonly used, although a great deal of asbestos is recovered from underground mines. In open-pit mining, waste rock of the overburden (various thicknesses) is removed and the ore is systematically blasted free. Some selection is practiced regarding which ore fraction goes to the mill for processing and which is determined to be waste rock.

Grizzlies (coarse screens) are commonly used to sort ore by size--larger pieces being recycled for blasting to manageable size. At the mill, the roughly sized ore is crushed to minus 6-in. size and further reduced to an appropriate size by secondary crushing and screening. An appropriate size ranges between 3/4 to 2 in. depending on the fiber length of the asbestos.

In contrast to the ores destined for milling, some ores, generally long-fibered chrysotile, are hand sorted (hand cobbled) at the mine. This select material may be sold directly to consumers for processing within consumer mills.

The principles involved in asbestos ore dressing are about the same for all types of asbestos (chrysotile and amphibole types) although cross-fiber asbestos processing differs somewhat from slip-fiber and mass-fiber asbestos processing. Inappropriate ore dressing methods degrade the fibers in the ores. Invariably, asbestos ore dressing consists of a number of rock comminuting steps and extraction of fibers at every step. Each step is marked by crushing, screening, and the drawing off of fibers by air aspiration. Both dry and wet methods of ore processing are practiced with the dry method being the most common one.

Oversize material from screening is routed to additional crushing from where it is sent on to join with undersize material from the first screen on the second screen. Three or four crushing and screening steps are

worked in series and fibers are drawn from each screen by suction as they come from the crusher or as they are freed by the action of the vibrating screens. Comminuted ore passing the last screen is generally waste rock (sand size) and is routed to the dump.

Asbestos fibers drawn from screens are routed by the air flow to classifiers (usually of the cyclone type) where fine rock and dusts are removed. Fibers are subsequently cleaned and classified to length, packaged, and stored prior to sale and shipment. The milling sequence is expected to maximize the recovery of each fiber grade.

A simplified process flow diagram is presented showing the major process steps used in the dry milling of cross-fiber asbestos ores.

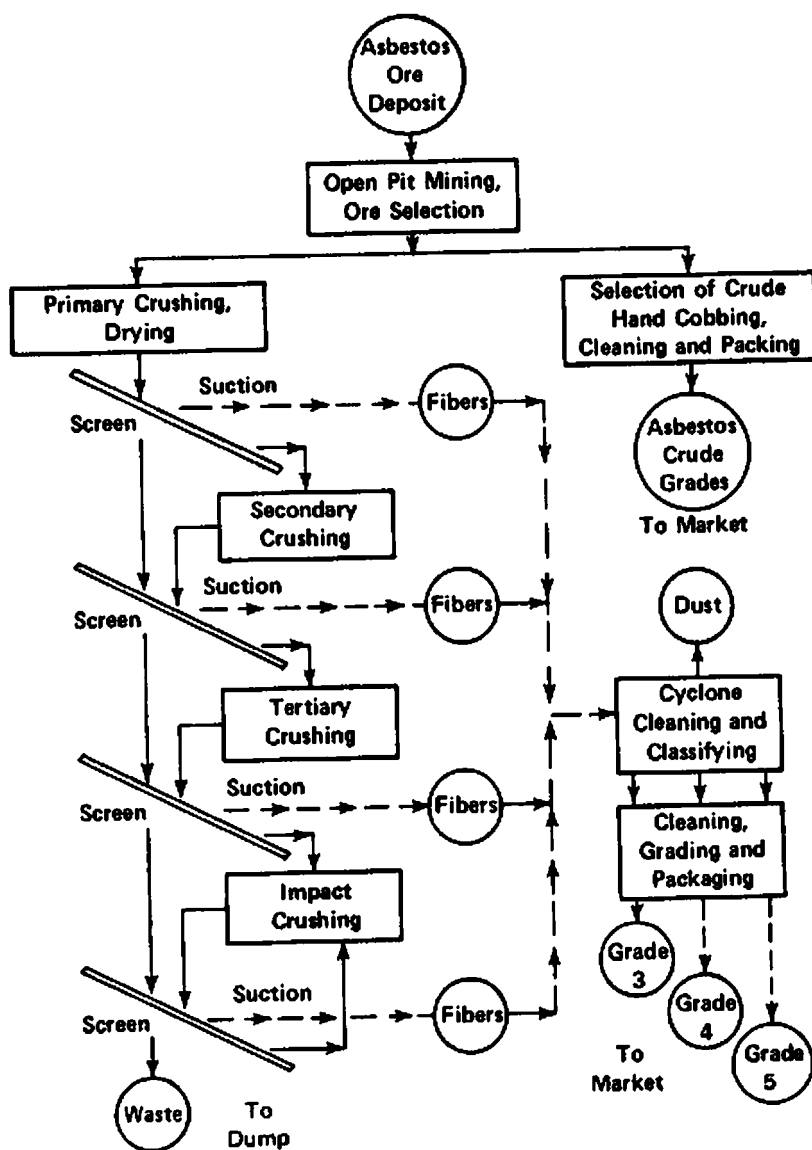


TABLE 1.7. ASBESTOS APPLICATIONS *

Raw Asbestos

Yarn	Thread
Wick packing	Rope packing
Felt	Paper (plain and corrugated)
Rollboard	Millboard
Insulating wire	Compressed sheet packing
85% Magnesia pipe covering, blocks and locomotive lagging	High temperature insulation (molded or various types)
Compound for encasing of motor windings	Molded composition for electrical and other purposes
Molded brake lining and brake blocks	Automobile bodies and railway sleepers (molded composition)
Reinforcement in plastics	Filler in plastics
Flooring	Pottery and sculpture
Asbestos cement products	Plaster and stucco
Paints, varnishes and fillers	Sprayed asbestos (acoustical)
Filling for asbestos mattress in- sulation	Insulation of batteries (loose fiber)
Insulation of walls and floors (loose fiber)	In foundations (to resist shock)
Insulation in underground con- duits (loose fiber)	Packing for explosives or other materials
Wadding in cartridges and timing devices	Filter fibers and filter pads
Platinized asbestos fiber for filter- ing	Coating for welding rods
In cheese making (spores are placed on asbestos)	Sewer pipe
Asphalt floor tile	Automobile body undercoating
Adhesive	

Asbestos Yarn

Cloth	Tape, electrical and other
Brake lining	Clutch facings
Packing, valve stem, braided and other	Gas mask filters
Gaskets and gasket cloth	Tubing
Wick for oil burning apparatus	Rope
Twine or sewing thread	Stocking for lead cable
Electric fixture wire covering	Electric cable covering
Typing gas mantles	Spark plugs
Edges for hair felting	Steam hose
Fire-retardant hose	

Asbestos Tape

Wick for oil burning apparatus	Belts for conveying hot glass or other articles
Pull strings for ovens	Insulating locomotive steam pipes at bends, etc.
Insulating armatures	Winding coils
Winding bus bars	Insulating underground cables
Such laboratories uses, as insulation for flasks, test tubes, retorts; tie straps in diffusing materials	
In glass manufacture for wrapping tines of forks to take bottles from ovens	
Insulating electric wires on planes and ships	

Wick Packing

As packing	For piping of wire, armor plate or galvanized materials
------------	--

Asbestos Cloth

Packing, sheet, high pressure, folded or wound	Brake lining, folded and stitched
Clutch facings	Gaskets
Asbestos insulation mattresses	Substitute for canvas on insulation where temperatures are high (lagging cloth)
Clothing, suits, gloves, leggings	Helmets
	Aprons
	Berets
Draperies	Hangings for firestops
Blankets for fire fighting	Blankets in electrolyzer cells
Bags and diaphragms (in oxygen producing)	Mailbags
Awnings	Rugs
Theatre curtains	Theatre scenery
Floor lining in theatres	Portable motion picture booths
Motion picture screen	In acoustical treatment
In acetylene welding	Gun grips
Asbestos faced wipers in commutators	Facing for dryer felt
Filtering (fruit juices, acids, etc.)	Filter in dust collectors
Oil filter sack (in automobiles)	Protectors for gas bags in balloons
Oven insulation	Lining in motors
Lining of laboratories, cooling chambers and other rooms	Plastics
Lining of automobile footboards	Padding for laundry presses and mangles
Padding, prison cells	Wrapping oil tanks and oil lines in engines
In various medical test apparatus	Umbrellas and shields (protecting firemen)
Sand bags (for pressing hats)	Conveyor belting
In hay curing to preserve aroma and color	In cheese making to control temperature
Insulation against noise and vibration (especially in airplanes)	Fittings for airplanes
Ironing board covers	

Asbestos Felt

In acoustical work	Protection of underground pipe
On paper machines	Noise insulation
Padding in pianos	Plastics
Adhesives	

Asbestos Paper

Air cell and other pipe coverings	Boiler jackets
Asbestos felt roofing	Asbestos built-up roofing
Asbestos protected metal roofing	Gaskets, plain and metallic
Wick in oil burning apparatus	Tubes in electrical industry
Wrapping of electrical wire	Wrapping of hot air pipes
Linings of stoves and heaters	
Linings of:	Cartridges
Filing cabinets	Carpets
Soldiers' helmets	Radiator covers
Auto mufflers	Cookers
Drum controllers	
Electric appliances	Motors
Armored car roofs	Insulation of ovens and dry kilns
In enameling ovens to catch drip	Tank covers
Diaphragm in electrolytic cell	Filtering
Reinforcing aluminum foil for insulation	
In window glass machinery to guide hot sheets; to shield hot glass from flying fragments	In chemistry and physics in many various ways
In welding and other processes for protection from heat	Reinforced with cotton thread for automobile tops
In annealing (crumpled paper)	Wrapping of wires and cables
Covering of rockwool blankets which must be sewed	

Asbestos Paper (Continued)

Insulating exhausts on automobiles	Baking sheets
Table pads and mats	Construction air ducts or lining of paper ducts

Asbestos Millboard

Stoves and heaters	Safes
Garages	Motion picture booths
Electric switch boxes	Dry cleaning machines
Garbage incinerators	Hoods of automobiles
Bottoms of brooder stoves	Ovens and dry kilns
As fireproof wallboard	Ceiling over boilers, smoke stacks, etc., for fire protection
Gaskets, plain and metallic	Paddles in glass mills
Washers in electrical apparatus	Tent shields and stove pipe rings
In metal clad doors (between outside metal and wood core)	
Table pads and mats	Stove mats

Asbestos-Cement, Flat Sheets, and Wallboard

Interior sheathing (of factories, refrigerator rooms, etc.)	Exterior sheathing (half-timber effect)
Partitions, movable and fixed	Portable buildings
Brick-type siding	Semiportable motion picture booths
Roofs and sides of small buildings	Fire protection around engines
Fireproof layer on insulated board	Backing for dies (in molded glass)
Lining of fireless cookers	Hoods over machines or vats (from which vapor rises)
Brake shoes for elevators	Laboratory table tops
Mounting of test instruments and gages	Cabinets and panel box work
Switch boards	Miscellaneous uses in electrical apparatus
Insulators between phases and on arc deflectors	Spark arresters
Electric motor casings	Backgrounds and cutouts for window displays
Lining for bleaching and other tanks and vats	
Blackout or bombproof board	

Asbestos Cement Pipes

For carrying of water, sewage, gas and special liquids	Conduits for electric light wires, etc.
As gas vent pipes	Purlins, rafters, trusses, etc. for wartime buildings

Asbestos Composition Material

Insulation compounds	Heater cord insulation
Electric wire insulation	Missile and aircraft plastics
Lamp sockets, rheostat backings, switch parts, arc deflectors, resistance mountings and other electrical uses	
Underground insulation	Flooring
Phonograph records, buttons and other small objects made of plastic	Sealing of percussion caps in large cells

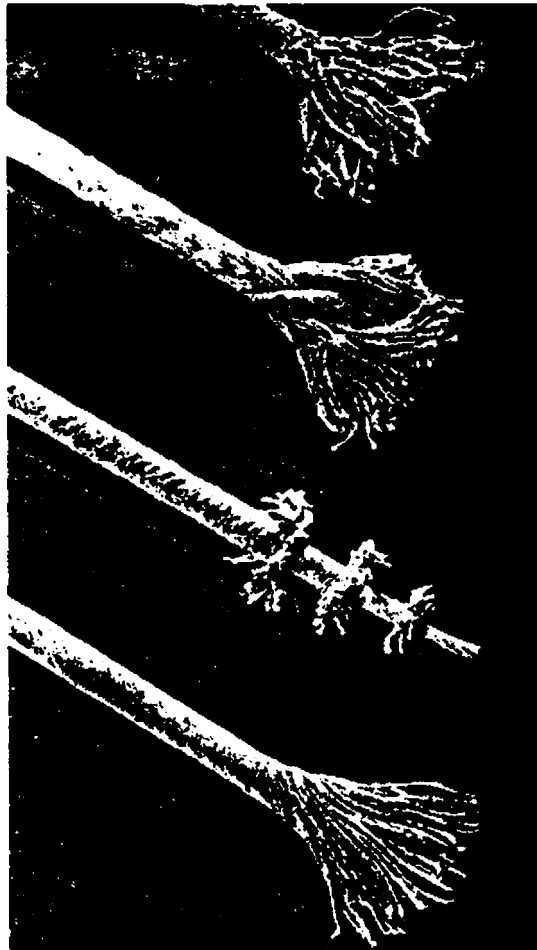
Asbestos Products in Theatres

To localize fires in location	To protect nearby buildings when fires are set
For wall sections in sets to prevent reverberation	
Firebox in fireplaces	Insulation of camera booths against sound
Blinders or ears for lights or sun arcs	Dressing winter scenes as snow
Dust on cobwebs, old wine kegs, etc.	Noise insulation
Insulation for maintaining even temperature	

TABLE 9.1. SOME USES OF ASBESTOS IN PLASTIC COMPOSITIONS *

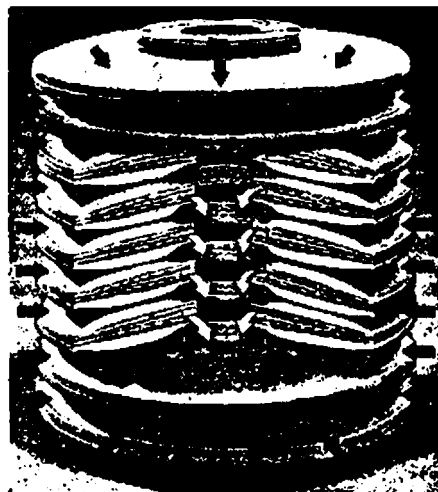
Type of Resin	Use	Method of Fabrication
Rosin, with or without waxes, gilsonite, creosote, shellac, mineral oils, phenolic resins, etc.	Electrical insulations Box toe compositions Roofing compositions Laminated boards	Hot molding, chilling Hot molding, chilling Hot pressing, chilling Hot pressing, chilling
Shellac, with rosin, creosote, lime, etc.	Electrical insulations and miscellaneous uses	Hot molding, with or without chilling
Asphalts, tars and pitches, with chlorinated rubber, oils, solvents, etc.	Heat insulator coatings for metal pipes Parts for electrical and heat appliances	Brushing Drying, cold molding, using waterproofing molding
Waxes (Montan, carnauba, etc.) with shellac, natural resins, gilsonite, modified rosins, mineral oils, etc.	Casting, coating, molding Box toe compositions Roofings	Hot molding, chilling Hot molding, chilling Hot pressing, chilling
Polymerizable oils	Joints, coating compositions, etc.	Brushing, trowelling, etc., curing
Rubber or chlorinated rubber, with or without alkyd resins, etc. with or without organic filler and asbestos	Brake linings, clutch facings, valve discs, gaskets, packings, etc.	Hot molding, curing
Phenolics, alone or with natural resins, rubber, inorganic filler (silica or mica) and asbestos, floats, long fiber, paper, yarn or fabric	Laminated boards Friction materials, automotive applications, etc. "Havag" type compositions Coating compositions, books, papers, etc.	Hot pressing Hot molding Hot molding Curing
	Molded heat resistant compositions Impregnated sheets, panels, or boards, gaskets, valve discs, etc. Asbestos fabric pressed as blocks Asbestos sheet as spacers for heat insulators Asbestos yarns, etc. for clutch facings, etc.	Hot molding Laminated under heat and pressure Heat and pressure Hot pressing Hot molding
Cellulose esters	Asbestos and cellulose esters used to increase strength and toughness of glycerol phthalate molding compounds	
Alkyd resins	Commutator rings Mica sheets Brake linings Door stripes, electrical spools, etc. Structural tiles Wood veneer panels Acid proof coatings	Hot molding, chilling, curing Hot molding, chilling Cold molding, curing
Phenolic varnishes	To increase adherence to coated surface, to increase flexibility of undercoatings, on metal surfaces, also used in packings, putties and boards	Varies depending on application
Sheet protection for metal surfaces	Asbestos paper or sheet is connected to metal surface by phenolic resin and then coated with the same material	Curing by heat and pressure

* A. B. Cummins, "Asbestos in Plastic Compositions" *Modern Plastics*.



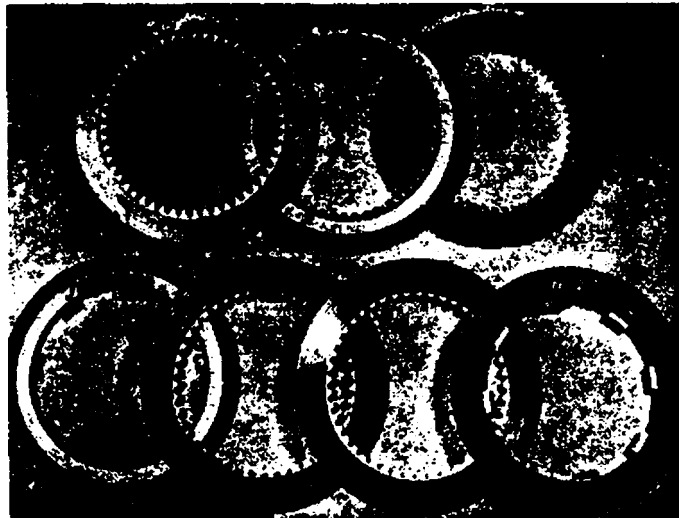
(Courtesy Johns-Manville Corp.)

Figure 10.1. Asbestos braided and woven packings—from top to bottom—interlocked braided, square-plaited braid, braid over braid, and twisted.



(Courtesy Alsop Engineering Corp.)

Figure 11.1. Cut-away view of cartridge filter for water, fuel, and industrial oils using asbestos base filter discs. Arrows indicate liquid flow.



(Courtesy Raybestos Manhattan, Inc.)

Figure 7.2. Automatic transmission clutch plates consisting of wafers of asbestos-metallic material, cork, and treated paper material, paper material or steel material bonded with thermosetting adhesives to steel plate.



(Courtesy Johns-Manville Corp.)

Figure 7.3. Asbestos woven and molded brake linings, clutch facings, cone facings and segments.

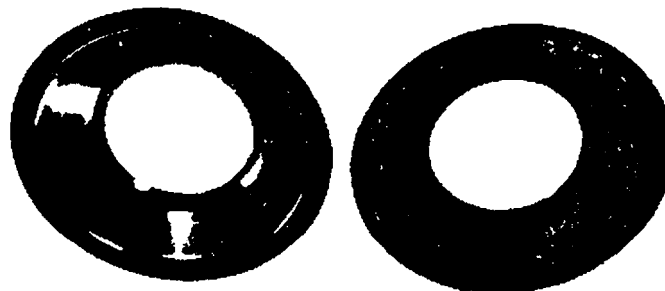
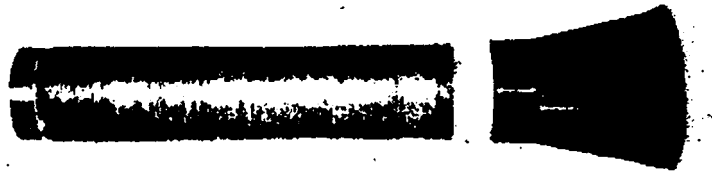


Figure 2.1. Rocket motor aft (asbestos-phenolic insulator) before and after firing at 5,000°F.



(Courtesy The Bristol Aeroplane, Ltd.)

Figure 9.9. A rocket motor tube tailpipe fabricated from asbestos-phenolic plastic.

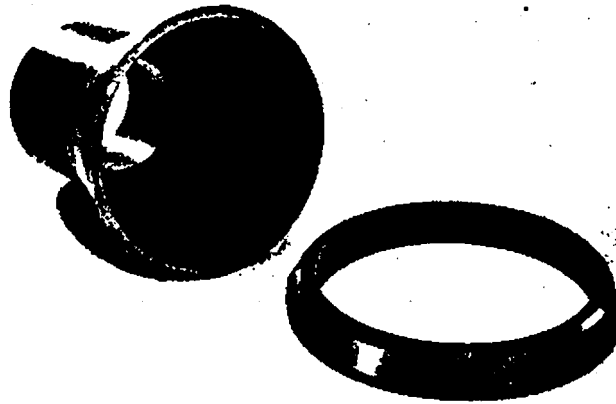
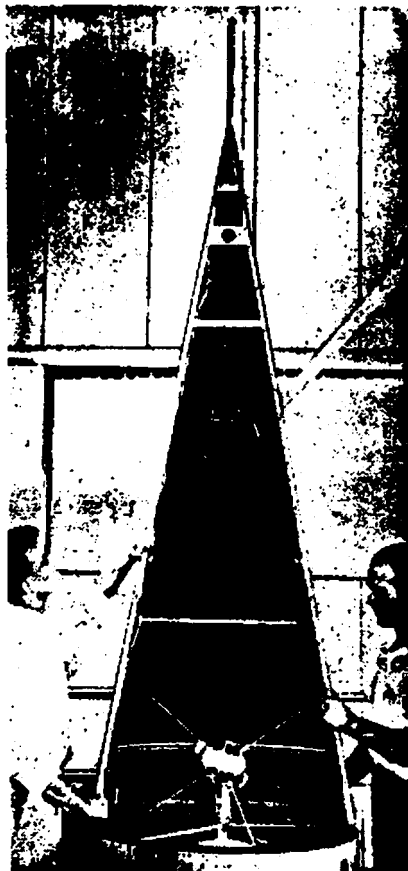


Figure 9.10. Rocket motor body asbestos-plastic exhaust cone and ring.



(Courtesy The Martin Co.)

Figure 9.2. Vanguard rocket nose cone is made of asbestos-phenolic material. It is subjected to aerodynamic heating, shock heat, and structural loads. The two-piece cone splits apart and drops off after the rocket leaves the atmosphere.



(Courtesy The Thiokol Corp.)

Figure 9.8. The Nike-Hercules sustainer motor contains asbestos-phenolic insulation from the forward end to the exhaust end.



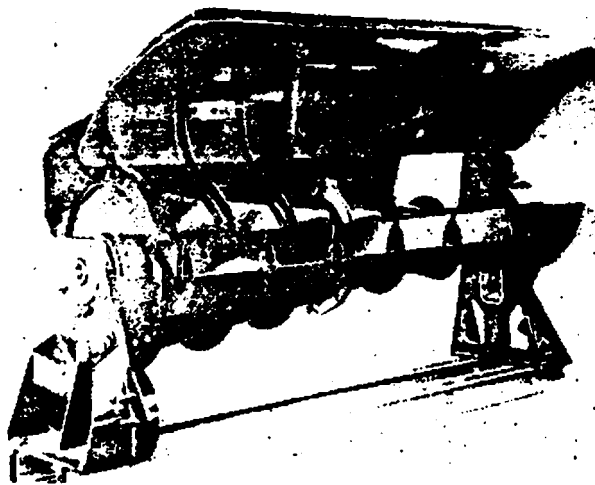
(Official U. S. Navy Photo)

Figure 1.8. The Vanguard satellite rocket (Cape Canaveral, Florida) shown at take-off. Asbestos parts include 6½-ft. nose cone, electrical and thermal insulation, conduits, etc.



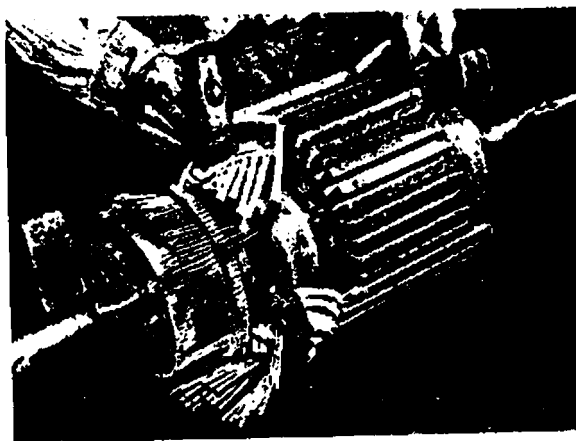
(Courtesy The Bristol Aeroplane Co., Ltd.)

Figure 9.11. Asbestos base plastic 75-gal drop tank for the Hawker Sea Hawk. This tank is the first plastic drop tank in the world to have received full design approval.



(Courtesy The Bristol Aeroplane Co., Ltd.)

Figure 9.4. High-speed radar scanner manufactured from high-pressure asbestos-phenolic plastic.



(Courtesy Johns-Manville Corp.)

Figure 6.1. Installation of Quinterra wrapped coils in electric motor armature.



(Courtesy Mine Safety Appliances Co.)

Figure 1.10. Aluminized asbestos fabric used in safety clothing for hot spots—furnace repair, coking, working white hot ingots, etc.