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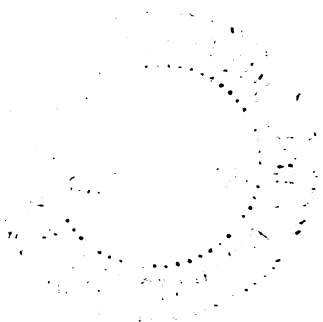
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Bureau of Mines

The data base for forecasts and the long-term analysis of commodities terminates with 1973, the last year for which relatively complete world-wide data were available. However, to improve timeliness of chapters, all appropriate information at the time of final preparation is included. Sources of current information published by the Bureau of Mines and other organizations are listed at the end of this chapter.





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ASBESTOS

By Robert A. Clifton[1]

The United States' claim of being the world's largest consumer of asbestos is possibly no longer valid, as the U.S.S.R. likely consumes as much or more. (See figure 3.) The construction industry presently uses the majority of asbestos fibers in such products as asbestos cement pipe and sheet, roofing products, flooring products, paints, and caulking, and should remain the largest user. U.S. mines produced 13 percent of consumption needs in 1974. Canada is the leading supplier of asbestos imports, about 95 percent, with the Republic of South Africa second. South Africa supplies all of the U.S. demand for crocidolite and amosite, and the majority of imports from there are these fibers.

The rate of growth in the use of asbestos continues higher in the developing countries. Asbestos reserves could well be in danger of depletion by the year 2000 at the forecast rates of consumption, if the "find" rate of new sources does not increase.

Canada should remain the world's leading producer as activity in exploration, evaluation, and development of asbestos deposits remains high. United States demand shows no signs of abatement even though the domestic production has been seriously curtailed. There are several new inorganic fibers available, but they pose no serious threat to the major asbestos markets. The present, and possibly chronic, world shortage, coupled with a growing demand/reserve ratio, suggest the need for research to find adequate substitutes.

The health hazards associated with asbestos are undergoing close scrutiny by the Federal and local governments, unions, industry organizations, and concerned environmentalists. The many areas of controversy give promise of prolonged dispute. Efforts to regulate conditions to minimize the hazard are given as a reason for the possible loss of a viable asbestos production industry in the United States.

INDUSTRY STRUCTURE

Canada, with major activity in the Province of Quebec, leads the world in both total quantity produced and the size of individual mines and mills. The U.S.S.R. is also a major world asbestos producer. The Republic of South Africa, the People's Republic of China, Italy, and the United States mine substantial tonnages and, in combination with Canada and the U.S.S.R., produce over 90 percent of the world's supply. Chrysotile is the variety wanted by over 95 percent of the world's consumers. Most of the data in this report relate to chrysotile, and hereafter the term "asbestos" will mean chrysotile unless otherwise designated.

Total world production in 1974 was 4.5 million tons of all grades and varieties (table 1). Canada's share of this was 40 percent, the U.S.S.R. an estimated 33 percent, the Republic of South Africa 8 percent, the People's Republic of China 5 percent, Italy 4 percent, and the United States 2 percent. Recent published data on world production are not crediting U.S.S.R. production with the lower grades that have other than fiber uses.

Geographic Distribution

In 1963 the one major asbestos-producing mine in the United States, GAF's Lowell mine in Vermont, was joined by another of similar size and output in California, plus three other lesser mines also in California. In 1974 all of the major producers operated, but in California, the largest mine and a lesser one closed. Environmental regulations have been cited as a contributing factor. Significant production may be limited to Vermont and the Coalinga area of California.

An area roughly 75 miles long and 5 to 6 miles wide beginning 80 miles east of Montreal, Canada, and continuing eastward contains not only the world's largest mine and mill, but, in toto, the largest concentration of deposits in the world. Mergers and closings have reduced the number of operating companies to five in this "Eastern Townships" region stretching from Danville to East Broughton, Quebec. Four of the

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companies are either totally or partially owned by U.S. corporations, most of which manufacture asbestos-containing products. New Canadian mines continue to be opened. The latest, in 1973, was the Asbestos Hill mine of the Asbestos Corp. in northern Quebec on the Ungava Peninsula. Canadian production in 1974 totaled 1,824,000 short tons; that of the United States totaled 112,533 short tons.

Most of the Soviet-produced asbestos is used domestically or in other countries that have centrally controlled economies. The large mine and mill complexes in the Bajenova district of the Urals, the Dzhetygara mine in Kazakhstan, and Ak-Dovurak in Tuva are to be joined by the Kiembay combine under construction in Orenburg Oblast and the planned development of the Molodezhnoye and Il'chirsk deposits at Buryat. A new combine in Kazakhstan is to be a joint venture with several COMECON nations as partners.

Rhodesian chrysotile deposits retain great importance in the world market. The generally tight supply would assure this, but the real worldwide shortage of spinning-grade fibers accentuates the picture. Neither the Arizona nor the British Columbia mines can supply all of the U.S. demand. Imports of the low-iron spinning-grade fibers needed in the electrical insulation and textile segments of the industry are now entering under the "Byrd Amendment," which exempted strategic materials from the United Nations sanctions against Rhodesia. Swaziland and the Republic of South Africa are also major producers of chrysotile. South Africa is presently the sole producer of amosite and crocidolite, which are in diminishing demand. "In continent" use of African asbestos is increasing, but the large majority still is sold on the world market.

Seven mine and mill operations were run by as many companies to produce asbestos in the United States in 1974. Four of the operations were in California and one each in Arizona, North Carolina, and Vermont. The California companies are Atlas Mineral Corp., Coalinga Asbestos Co., Inc. (Johns-Manville—now closed), Pacific Asbestos Corp. (H. K. Porter—now closed), and Union Carbide Corp. Jaquays Mining Corp. operates in Arizona, Powhatan Mining Co. in North Carolina, and Vermont Asbestos Group, Inc., in Vermont. Total employment was 380.

The fully integrated Johns-Manville Corp. is the largest asbestos producer in Canada, and is such a factor in the world market that it is considered to be the price leader. Johns-Manville's many manufacturing plants in the United States use large quantities of asbestos as a raw material.

Table 1.—World asbestos production, 1973, and capacity, 1974 and 1980

(Thousand short tons)

	Production [1] 1973	Capacity 1974	Capacity 1980
Chrysotile:			
North America:			
Canada	1,974	2,047	2,567
Mexico	----	----	50
United States	150	158	55
Total	2,124	2,205	2,672
South America:			
Argentina	1	1	1
Brazil	44	46	70
Total	45	47	71
Europe:			
Bulgaria	3	4	5
Finland	12	17	20
Italy	165	173	180
U.S.S.R.	1,411	1,482	1,900
Yugoslavia	10	19	40
Other	3	4	5
Total	1,604	1,699	2,150
Africa:			
Rhodesia	88	100	100
South Africa, Republic of	75	79	100
Swaziland	41	48	55
Other	1	1	1
Total	205	228	256
Asia:			
China, People's Republic of	230	250	300
Cyprus	29	35	40
India		16	30
Japan	15	26	25
Korea, Republic of	6	7	7
Taiwan	3	4	4
Turkey	5	6	6
Total	300	344	412
Oceania: Australia	35	73	100
World chrysotile total	4,313	4,596	5,661
Crocidolite:			
South Africa, Republic of	168	194	200
Australia	----	21	21
World crocidolite total	168	215	221
Amosite: South Africa, Republic of	117	120	130

[1] 1973 production was at capacity.

Turner & Newell, Ltd., based in Manchester, England, is another fully integrated company with worldwide operations. Its mines are in Rhodesia, the Republic of South Africa, and Canada. Its Canadian subsidiary, Bell Asbestos Mines, Ltd., has a mine at Thedford, Quebec, and a large minority holding in Cassiar Asbestos Corp., which has mines in British Columbia and the Yukon. Bell acts as selling agent for Cassiar.

Much of the world market for asbestos from the Republic of South Africa is met by the Cape Asbestos Co., Ltd., London. This fully integrated company developed the mines there to feed its asbestos products plants in Europe and North America.

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Definitions and Grades

Asbestos is a name applied to a group of naturally fibrous minerals. The principal variety is chrysotile, a hydrous magnesium silicate having the theoretical formula $3MgO \cdot 2SiO_2 \cdot 2H_2O$. Other commercial varieties are amosite, a complex iron-magnesium silicate, $(FeMg)SiO_3 \cdot$ 1–5 percent H_2O; and crocidolite, a sodium-iron hydrous silicate, $NaFe(SiO_3)_2 \cdot FeSiO_3 \cdot H_2O$. Of minor importance are tremolite, $Ca_2Mg_5Si_8O_{22} \cdot (OH)_2$, and anthophyllite, $(MgFe)_7Si_8O_{22}(OH)_2$ (*1*)[2].

Chrysotile, the principal variety of commerce, is graded and grouped according to fiber length. Most of the groups are divided into several subgroups to comprise the commercial specifications. One producer alone offers to its customers 420 grades of fibers in 1,320 different forms (*9*). For some uses, the chemical composition is important. Thus, for electric insulation an upper limit for the iron content may be specified. The methods of classification used in the principal producing countries are discussed in detail in a Bureau of Mines bulletin (*2*).

USES

All uses of asbestos are as processed fiber. The processed chrysotile fibers are placed into the following groupings, which are based upon length of fiber:

Groups 1, 2, and 3—These groups are composed of the longest fibers; the major end use products include textiles, clothing, theatre curtains, different types of packings, in the manufacture of fire-proof textile products, woven brake linings, clutch facings, electrical insulation materials, and high-pressure and marine insulation.

Group 4—Its major use is in asbestos cement pipe, which is used mainly in transporting water, such as in municipal water works, irrigation and conservation projects.

Group 5—This group is used in asbestos cement sheets, flat and corrugated sheets, low-pressure asbestos cement pipes, and molded products; it is also used in some paper products such as pipe insulation, wrappings, and other products, including brake linings and gaskets.

Group 6—The main consumption for this group is in asbestos cement products mix, gaskets, brake linings, vinyl sheet backings, and millboard.

Group 7—The group is used in molded brake linings and clutch facing as a filler in vinyl and asphalt floor tile, in asphalt compounds, joint and insulation cements, roof coatings, plastics, and caulking compounds.

Asbestos products plants are located in 16 States, principally in the eastern southern, and West Coast areas.

Amosite is used for felted insulation in blanket form for high-temperature service up to 900° F. A loosely compacted form is applied as a covering for marine turbines, jet engines, and similar applications.

Amosite is also used as a constituent of 85-percent magnesia insulation and lightweight, fire-resistant marine partition board.

Long-fiber crocidolite (blue asbestos) is woven into fabrics for locomotive boiler lagging (in Great Britain) and for acid-resistant packings and gaskets. The principal use of the shorter crocidolite fibers is in making asbestos-cement pipe.

Tremolite and anthophyllite are used for chemical-resistant filters, as welding-rod coatings, and as fillers in various products.

Asbestos is adaptable to more than 2,000 uses. Because of its high strength-to-weight ratio and resistance to searing temperatures, it is used in rockets and missiles.

World end-use patterns are not discernable from available data, and projections of U.S. patterns to the rest of the world cannot be justified. In 1970, one authoritative journal (*8*) reported that 70 percent of the world's asbestos was connected with products used in the construction industry. This still seems reasonable and can be used for planning purposes. The remaining 30 percent is divided among a myriad of uses.

RESERVES-RESOURCES

Current information leaves doubts as to whether the United States has any real "economic reserves." In 1973 the asbestos production industry operated at record highs in both volume and price of product. Since then the closure of the largest mine was barely averted. The actual closing of the next largest and the fifth largest occurred for a total loss of nearly 40 percent of asbestos production. It would seem that the cost of meeting environmental standards may help reduce most of the asbestos reserves to the "subeconomic" level.

The possible million tons of asbestos fiber at the Copperopolis, Calif., deposit are subeconomic at present. The future of the millions of tons of short fibers available in the Coalinga, Calif., area is doubtful, as one of the three operators there has shut down.

The world picture seems better than the domestic one. The year 1973 saw demand outstrip the capacity to produce for the first

[2] Numbers in parentheses refer to items in the list of references at the end of this chapter.

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Table 2.—Identified world asbestos resources
(Million short tons)

	Reserves [1]	Other	Total
North America:			
United States	9	65	130
Other	56		
Total	65	65	130
South America	5	4	9
Europe	52	20	72
Africa	22	14	36
Asia	7	8	15
Oceania	9	4	13
World total	160	115	275

[1] Based on average U.S. price of asbestos in 1974 of $122 per ton.

time in recent years. Johns-Manville's Jeffrey mine, the world's largest, had sold its total year's production by August. The year 1974 saw a slight reduction in American consumption and Canadian production and 1975 was a bad year for both. The landslide at Jeffrey mine and the 7 months strike at the mines around Thetford Mines reduced Canadian production to 63 percent of that in 1974. During the strike, 55 percent of normal U.S. consumption supply was disrupted. This will heighten the world demand which, without this aberration, gave indications that it could seriously threaten world resources by the year 2000.

Geology

Most chrysotile asbestos deposits, including those of Vermont and California in the United States, Canada, Southern Rhodesia, Swaziland, the Republic of South Africa, and the U.S.S.R., consist of irregular cross-fiber veins (closely packed fiber set at a right angle to the faces of the rock fractures) or slip-fiber zones (shear planes in rock, filled with fiber, matted together parallel to the seam) in massive serpentine. Such deposits commonly extend to unknown depths. Those of Arizona, however, consist of more or less horizontal asbestos-bearing serpentine zones in thin-bedded limestone. Such deposits are generally less extensive and less persistent than those in massive serpentine. The amosite and crocidolite of the Republic of South Africa occur in banded ironstones that are so folded and contorted that the veins are very irregular.

TECHNOLOGY

Exploration and Development

Exploration and development are apparently on the increase throughout the world because of the increasing demand for asbestos fiber and lack of production capacity to meet that demand. At least one major company is actively exploring some possible sites in the contiguous 48 States, but interest in the Eagle Quadrant showings in Alaska seems dormant.

Exploration in Canada remains quite active with some of the large metal-mining firms joining the asbestos firms in the search for new asbestos deposits.

Mining

In Vermont and in the Copperopolis district in California, the fiber-bearing rock is removed from an open pit; but in the Coalinga district of California, the highly sheared ore is simply "plowed" and allowed to air dry, and the coarse fraction is screened out from the mill feed. In Arizona, a heading is driven beneath the fiber zone, which is later blasted down and milled. The Canadian mines generally are open pits. The chrysotile of Southern Rhodesia, the Republic of South Africa, and Swaziland is obtained from underground mines. Amosite is obtained chiefly from large underground workings, and blue (crocidolite) asbestos from small open pits and shallow mines. The Soviet deposits are worked both in open pits and underground. Cyprus has large open pit workings.

The data (*10*), analyzed by linear regression and depicted in figure 1, tell a very interesting story about asbestos recovery from established mines over a period of time. In 1951, in the Quebec asbestos mines, 75 percent of the rock mined was milled, and 9.9 percent of that milled was recovered as fibers. About 20 years later (1970), only 32.2 percent of the rock mined was milled, and yielded 6.1 percent fibers. Trend projection to the year 2000 indicates that only 24.4 percent of the mined rock will be milled and 2.9 percent fibers will be produced.

The many variables preclude prediction as to the point when these trends would produce subeconomic resoures, but they certainly portend escalating mining problems and costs.

Processing

Asbestos milling is a complex operation involving primarily the separation of fiber from rock and classification of fiber by length. There has been little change in the basic methods described in a previous Bureau of Mines publication (*3*).

Special milling techniques have been developed for the matted short fiber chrysotile of the Coalinga district of California, including grinding and wet-milling processes.

In Copperopolis, Calif., Vermont, and Canada, the mills are large and complex. The fiber is classified in many grades, such as spinning, cement stock, and paper stock.

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Table 3.—Characteristics of some fibers

Fiber	Crocidolite	Amosite	Chrysotile	Glass	Aluminum	Steel 5137
Tensile strength:						
kg/cm ^{2}	35,000	21,000	28,000	15,500	1,800	3,700
lb/in ^{2} x 10 ^{3}	500	300	400	250	25.6	52.6
Young's modulus:						
kg/cm ^{2}	172.2 x 10 ^{4}	153.3 x 10 ^{4}	155.4 x 10 ^{4}	73.0 x 10 ^{4}	70.0 x 10 ^{4}	190.0 x 10 ^{4}
lb/in ^{2}	24.6 x 10 ^{6}	21.9 x 10 ^{6}	22.2 x 10 ^{6}	8.5 x 10 ^{6}	9.94 x 10 ^{6}	27 x 10 ^{6}
Specific gravity	3.2	3.1	2.4	4.55	2.7	7.8

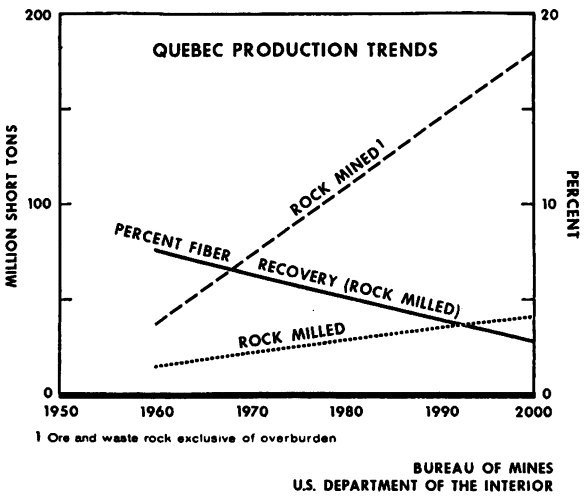


Figure 1.—Quebec production trends, from analysis of 1951–70 data.

A pressure-packing process is used in many mills, where asbestos fiber is packed under pressure in five-ply paper and/or woven vinyl bags. Each pressure-packed bag contains 100 pounds of asbestos and occupies about 2 cubic feet. With pressure packing, the asbestos measures 45 cubic feet per short ton.

Current Research

Research aimed at increasing the productivity of the personnel at asbestos mines and mills has been heightened by wage escalation rates unmatched by productivity rates. Larger equipment is one result. For example, at Johns-Manville's Jeffrey mine in Quebec, trucks of 200-ton capacity are used to haul waste, pit rock, and overburden (*11*). Trucks of 100-ton capacity are used to feed the ore to a primary crusher that can accept a truckload from each of two sides simultaneously.

Optimum fiber recovery has been a research goal that has paid dividends in two ways. The techniques have been so successful in recovering the short fibers, that former tailing piles have been reprocessed, have also significantly reduced dust levels in the mills and aided in worker protection.

Automation and computer control of the asbestos milling circuits are not only under study (*5*) but in operation. The new No. 6 mill at Jeffrey mine is a crusher-dryer-concentrator complex that is fully computer controlled (*11*).

The largest area of research concerned with asbestos for the last few years has been in connection with the controversial health aspects of the fibers.

The Bureau of Mines no longer has a research program aimed at either synthesizing analogues of the natural fibers or finding substitutes.

There are several synthetic inorganic fibers available commercially and more are becoming available each year; therefore, it is evident that private industry still hopes to capture the asbestos market with another fiber. Most efforts, though, seem to be aimed at the thermal insulation portion of the asbestos market. That this is a small portion of the market bears witness to the successes of mineral wool, glass fiber, and other substitutes. The most desirable characteristic of asbestos is its tensile strength. Table 3 from industry research (*4*) compares it with other fibers.

The exotic and very expensive whiskers are the only synthetic fibers that equal or surpass the strength of asbestos. Even the very newest inorganic fibers available commercially (*7*) have less strength than glass and cannot be considered as seriously competitive to asbestos.

The present shortages and projected demands indicate serious depletion of reserves by the end of the century. Accelerated research to find substitute fibers that will have at least some of the attractive asbestos characteristics of strength, chemical inertness, heat resistance, and economy in the same fiber seems needed.

SUPPLY-DEMAND RELATIONSHIPS

Components of Supply

During the entire history of the asbestos industry in the United States, domestic sources

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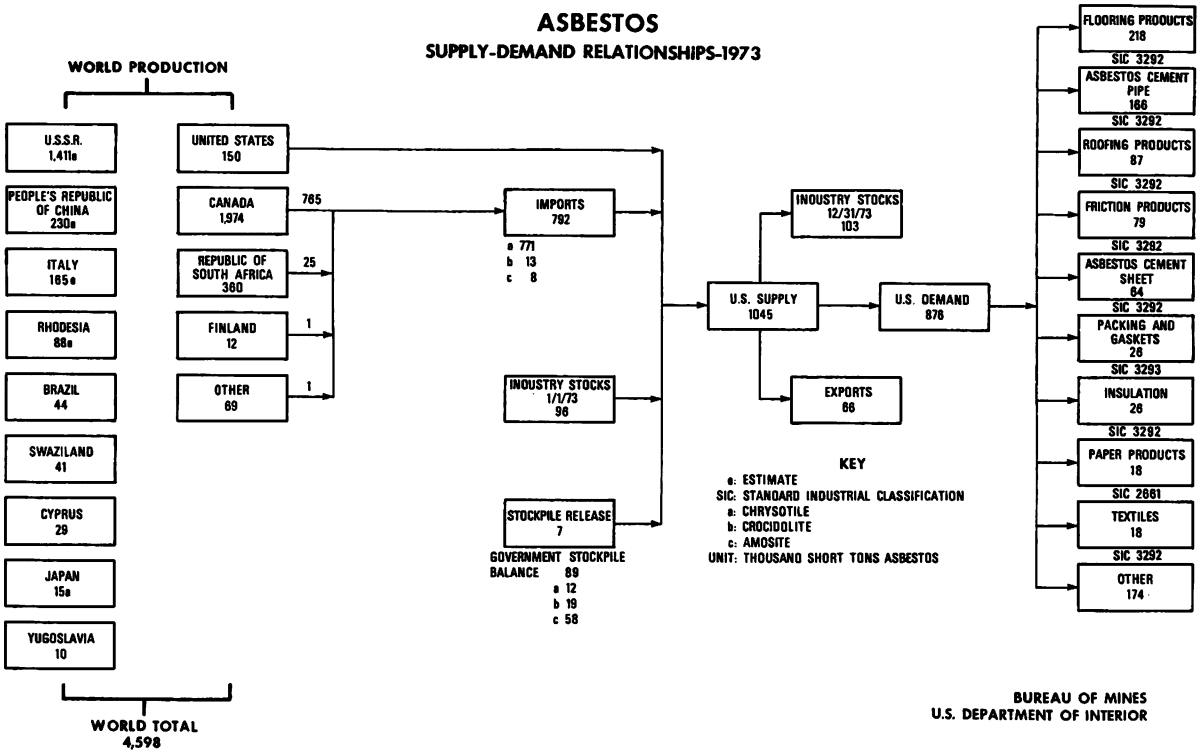


Figure 2.—Supply-demand relationship for asbestos, 1973.

have been able to meet only a small percentage of U.S. requirements. Vermont and the Copperopolis distrist of California have been the only consistent U.S. sources of Quebec-type asbestos. Both are predominantly producers of short fiber, but the Vermont asbestos mines produce about 500 to 700 tons per year of spinning-length fiber. Most of it is applied to nonspinning uses.

Canada furnished 96 percent of all the asbestos tonnage imported by the U.S. (1969–73) but only a small portion (3 percent) was spinning-grade fibers. The comparatively small quantities received from Africa are more important than would appear on a tonnage basis because they consist largely of special kinds and qualities unobtainable elsewhere. Under emergency conditions, imports of spinning fibers are of primary importance. Imports of spinning fibers from Canada average about 15,000 tons per year. The longer fibers of chrysotile suitable for spinning purposes represent a small fraction of the total production. Shortages of spinning-grade fibers have previously occurred, and this period saw another occurrence heightened by the Canadian strike.

Imports of amosite into the United States from 1969 to 1973 averaged about 12,000 tons per year. During the first 3 years of this period, the United States was purchasing for the national stockpile and total imports averaged above 14,000 tons. Government purchasing stopped, and the imports totals were halved for 1972 and 1973. A Presidential message of April 16, 1973 reduced to zero the stockpile objective for amosite asbestos but it remained on the national stockpile list of strategic and critical materials.

Imports of crocidolite advanced from 12,000 tons in 1954 to 24,000 tons in 1966, dropped to 7,000 tons in 1972, and were 11,000 tons in 1974.

U.S. and World Production

In 1973, U.S. production of asbestos fiber was at an alltime high; however, production in 1974 did not reach that level owing to the early 1974 closing of two California mines that represented about 40 percent of the 1973 production.

Canadian asbestos production continued to increase. Shipments in 1973 exceeded those of 1972 by 10 percent. However, there was a small decline in production in 1974 and that of 1975 was another 37 percent less. According to an article in Mining Engineering, new Canadian production capacity will reach 520,000 short tons by 1980 (*6*). A total of 1.15 million tons per year of new capacity is expected to be available in free world markets by 1980 (*6*). This includes 300,000 tons of Soviet exports and from mines

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Table 4.—Asbestos supply-demand relationships, 1965–74

(Thousand short tons)

	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
World mine production:										
United States	118	126	123	121	126	125	131	132	150	113
Rest of world	2,984	3,149	3,084	3,170	4,042	3,672	3,816	4,050	4,448	4,423
Total	3,102	3,275	3,207	3,291	4,168	3,797	3,947	4,182	4,598	4,536
Components of U.S. supply:										
Domestic mines	118	126	123	121	126	125	131	132	150	113
Government release	12	1	1	1	5	11	8	16	7	29
Imports, chrysotile	681	669	618	703	669	626	660	724	771	747
Imports, crocidolite	21	27	15	14	11	9	7	5	13	11
Imports, amosite	17	24	13	20	15	14	15	7	8	8
Industry stocks, Jan. 1	18	22	19	17	18	23	21	30	96	103
Total U.S. supply	867	869	789	876	844	808	842	914	1,045	1,011
Distribution of U.S. supply:										
Government acquisition	12	2	1	----	----	7	----	----	----	----
Industry stock, Dec. 31	17	15	20	18	24	20	29	46	103	103
Exports	43	47	47	41	36	47	54	59	66	62
Industry demand	795	805	721	817	784	734	759	809	876	846
U.S. demand pattern:										
Flooring products	200	202	179	204	196	184	191	202	218	153
Asbestos cement pipe	151	153	134	155	149	139	144	154	166	222
Roofing products	79	80	71	82	79	73	76	81	87	76
Friction products	71	72	65	74	71	66	68	73	79	80
Asbestos cement sheet	55	56	51	57	55	51	53	57	64	95
Packing and gaskets	24	24	22	25	24	22	23	24	26	29
Insulation	24	24	22	25	24	22	23	24	26	14
Paper products	16	16	14	16	16	15	15	16	18	63
Textiles	16	16	14	16	16	15	15	16	18	20
Other	159	162	145	163	154	147	151	162	174	94
Total U.S. demand	795	805	721	817	784	734	759	809	876	846

in Australia, Colombia, Greece, New Zealand, Mexico, and Brazil.

World asbestos fiber production totaled 4.6 million tons in 1973. (See table 1.) This can be assumed to be full capacity production because demand on the world market exceeded supply during most of the second half of the year. Linear regression analysis of production for the last 20 years gives an average annual growth rate of 2.03 percent; the same analysis of the last 10 years gives a 2.73 percent growth rate, and Vagt (*13*) predicts a 4.5-percent growth rate. It is interesting to compare present and estimated future capacity to predicted demand. The possible increase of 1.15 million tons of new capacity by 1980 will be used. Assuming 1973 production to be at capacity, the 4.6 million 1973 (base) production plus the 1.15 million potential would give a 1980 capacity of 5.75 million tons. Calculation of the 1980 demand using the 4.5-percent average annual growth rate shows a 6.25-million-ton demand or a 500,000-ton shortfall that would grow greater with every year. Even the lesser growth rate of the 10-year trend (2.73 percent) would barely suffice because the 1980 calculated demand at this rate is for 5.55 million tons in 1980.

The spinning grades of chrysotile asbestos produced in Southern Rhodesia were of great importance during World War II and the early postwar years because they constituted the principal sources of low-iron chrysotile suitable for shipboard electric-cable construction. They are of renewed importance each time, as now, that a spinning-grade shortage appears. The only new source of asbestos with substantive amounts of spinning-grade fiber that has become available in the postwar years is the low-iron deposit of chrysotile that was opened in 1953 in British Columbia.

Production of amosite in the Republic of South Africa has increased from an average of 20,000 tons per year during the 1940's to 100,000 tons in 1973.

At present, crocidolite is mined only in the Republic of South Africa. African production of crocidolite has increased from an annual average of 10,000 tons during the 1940's to 160,000 tons in 1973.

U.S. and World Consumption

Domestic asbestos consumption data are, starting in 1972, collected on a greatly revised form, which negates efforts at comparison with previous years. The fine cooperation of the industry has resulted in much more complete data than available heretofore, and further revisions of the form are imminent. The data in table 5 have been adjusted to reflect 96 percent of the apparent consumption. The 11 major uses are as follows: Asbestos cement pipe (26 percent),

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Table 5.—Asbestos distribution by end use, grade, and type, 1974

(Short tons)

	Chrysotile											
	Grades 1 and 2	Grade 3	Grade 4	Grade 5	Grade 6	Grade 7	Grade 8	Total chrysotile	Crocidolite	Amosite	Anthophyllite	Total asbestos
Asbestos cement pipe	----	----	92,600	20,300	----	72,300	----	185,200	36,400	1,100	200	222,900
Asbestos cement sheet	----	----	10,900	15,800	52,000	11,800	----	90,500	----	4,300	----	94,800
Flooring products	----	----	----	49,000	----	104,500	----	153,500	----	----	----	153,500
Roofing products	----	----	3,700	11,100	12,700	46,300	----	73,800	----	1,700	----	75,500
Packing and gaskets	100	1,900	7,500	7,500	1,400	10,300	----	28,700	100	----	----	28,800
Insulaion: thermal	----	100	900	100	3,400	2,800	----	7,300	----	1,800	----	9,100
Insulation: electrical	----	----	400	1,600	----	2,700	----	4,700	----	----	200	4,700
Friction products	----	5,600	1,300	29,500	6,300	36,600	300	79,600	----	----	----	79,800
Coatings and compounds	----	----	100	400	300	36,700	400	37,900	----	----	----	37,900
Plastics	400	1,000	900	800	----	7,500	6,300	16,900	200	----	700	17,800
Textiles	700	14,200	3,900	800	----	800	----	20,400	----	----	----	20,400
Paper	----	----	5,500	400	23,900	33,300	----	63,100	200	----	----	63,300
Other	----	300	1,100	----	2,300	32,700	----	36,400	400	500	----	37,300
Total	1,200	23,100	128,800	137,300	102,300	398,300	7,000	798,000	37,300	9,400	1,100	845,800

flooring products (18 percent), asbestos cement sheet (11 percent), friction products (9 percent), roofing products (9 percent), paper (7 percent), coatings and compounds (4 percent), textiles (2 percent), plastics (2 percent), thermal insulation (1 percent), and electrical insulation (1 percent).

World consumption of asbestos is increasing at a much faster rate than that in the United States. (See figure 3.) Maintaining the 4.5 percent predicted growth rate may not be possible within the limits of production capacity. The current economic recession has had no apparent effect on asbestos demand to date.

World Trade

If one were to remove the asbestos produced in the People's Republic of China (all is used domestically) and that produced in the U.S.S.R. (most of which is used domestically and in centrally controlled economies) from world trade consideration, a truer picture of Canadian prominence emerges. In the rest of the world, Canada had 67 percent of the market in 1973, the Republic of South Africa 12 percent, Italy 6 percent, and the United States 5 percent.

Canada's main markets are the United States and Europe, but there is a considerable trade in the Far East. South Africa sells most of its asbestos to European and African companies. The market for Italian asbestos is mainly in Europe.

Recycling

There are few (mainly textile) asbestos uses that have uncombined fibers in the end product. When these products are no longer useful, neither is the asbestos because of the physical and/or chemical changes that have made it a different mineral having less strength or shorter fibers of less value than reclamation costs.

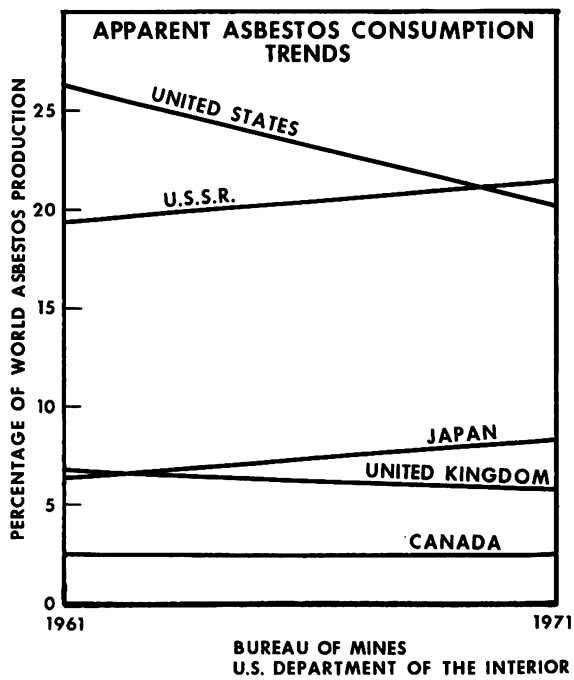


Figure 3.—Apparent national asbestos consumption trends.

Asbestos fibers in their common role of reinforcing a host matrix cannot be recovered.

Abestos is a nonrenewable natural resource with substitutes for only a few of its many uses.

STRATEGIC CONSIDERATIONS

During World War II, controls were in effect to restrict exports of asbestos needed in the military program. These controls were removed by executive order on September 10, 1945. During the Korean war, the supply situation again became acute, and in 1950 and 1951 controls were invoked that required licenses for export of all grades of asbestos. The license requirement was removed for the nonspinning

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Table 6.—Stockpile objective and Government inventories as of December 31

(Short tons)

	Stockpile objectives	Total inventories		Sales of excesses 1975
		1974	1975	
Amosite	None	46,593	42,815	3,778
Chrysotile	1,100	11,608	10,955	653
Crocidolite	None	2,478	32	2,446
Total	----	60,679	53,802	6,877

grades in 1953 and for the spinning fibers in 1954; however, export licenses still are required for shipments to nations that have centrally controlled economies.

The United States joined the United Nations embargo of Rhodesian products in 1967. By 1969 all Rhodesian asbestos except occasional small lots released from bonded warehouses or the government stockpile had disappeared from the U.S. market. In 1971 an exception to the sanctions for strategic materials, including asbestos, was enacted by Congress. By 1973 significant amounts of Rhodesian asbestos were appearing at U.S. ports.

Chrysotile is the only type of asbestos remaining on strategic stockpile lists, and the tonnage required for the spinning grades has been reduced to 1,100 short tons. The status of the asbestos in the stockpile as of December 31, 1975, is shown in table 6.

The United States is dependent upon foreign sources for 90 to 93 percent of its requirements for all grades of asbestos. The principal sources of low-iron, spinning-grade chrysotile asbestos are British Columbia in Canada and Rhodesia. A small amount of low-iron, long-fiber chrysotile is available from Arizona. The only source of commercial grades and quantities of amosite is a limited area in the Transvaal, Republic of South Africa. The United States is completely dependent on foreign sources for crocidolite. Although the United States is an importing country, there is some export trade because domestic producers have significant markets in Japan and Latin America. There are some reexports of foreign fibers.

The Asbestos Corp.'s bulk shipments of concentrate (30 percent fibers) from its Asbestos Hill mine in Canada to a new mill in Nordenham, West Germany, was novel. The operation, started in 1972, may portend other changes in the world market.

ECONOMIC FACTORS AND PROBLEMS

Prices and Costs

Asbestos continues its erratic price history. Prices for Canadian asbestos increased about 8 percent in 1973, 39 percent in 1974 and 23 percent in 1975. Quebec chrysotile fiber prices in 1975, f.o.b. mine, ranged from Can $89 per short ton for 7T, which is the shortest of the regular grades generally produced, to Can$1,463 for the longest of the milled fibers. Crude No. 1 was quoted at Can$3,496 per ton. British Columbia (Cassiar) sold for Can$216 for CZ to Can$2,916 per ton for Crude No. 1.

Table 7.—Time-price relationship for asbestos

Year	Average annual price, dollars per short ton	
	Actual price	Constant 1973 dollars
1954	82.34	141.72
1955	84.61	143.65
1956	89.78	147.42
1957	88.09	139.38
1958	90.50	139.66
1959	91.17	138.35
1960	94.62	141.44
1961	95.60	141.00
1962	94.85	138.26
1963	92.44	133.00
1964	98.70	140.00
1965	97.92	136.38
1966	100.63	136.35
1967	101.91	133.74
1968	98.93	124.75
1969	110.03	132.41
1970	115.64	132.01
1971	117.54	128.32
1972	116.63	123.16
1973	122.22	122.22
1974	122.27	110.90

Vermont chrysotile is produced in grades similar to those in Canada and ranged in price in 1975 from $72 for Group 7 to $418 for Group 4, f.o.b. mine. Arizona fibers ranged in price from $100 for Group 7 to $2,000 per ton, f.o.b. Globe, Ariz.

The average price for amosite, f.o.b. U.S. ports in 1974, were $228 per short ton; for crocidolite, prices averaged $251 per short ton.

The total value for the 112,533 tons of asbestos produced in the United States during 1974 was $13,759,000, an average of $122.27 per ton f.o.b. minesite. The imports of asbestos for consumption were valued at $124 million.

Linear regression analysis of a 10-year period of Canadian asbestos production as shown in figure 4 taken from the 1972 Minerals Yearbook can be informative. The marked divergence of the value and production lines shows graphically the inflationary trends. The upward slope of the production and export lines is indicative of the expanding world market. The slight divergence between the production and export lines illustrates that Canada's consumption growth rate exceeds that of production and that an increasing amount of Canadian asbestos is consumed domestically.

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Taxes and Tariffs

There are no special taxes on the asbestos industry. Producers are granted a depletion allowance of 23 percent on domestic production and 10 percent on foreign production. Domestic asbestos producers have no tariff protection.

Transportation

The Quebec and Vermont deposits are within easy rail haul to most of the plants manufacturing asbestos products in the industrial areas of the Eastern United States. The African deposits are remote from the principal markets and have high transportation expenses. Transportation from British Columbia, Canada, is costly. The Arizona producer has a difficult transportation problem. The mines are in the vicinity of Globe, the nearest railhead, with an average haul to the railroad of about 50 miles. The major consumption centers are in the Northeastern United States, and are much closer to Quebec, Canada, than to Arizona. Consumption of asbestos is growing along the west coast of the United States. Comparable growth of the industry has taken place in other areas where fiber from California would be competitive, in terms of freight rates, with that from Quebec.

Energy Requirements

The Bureau of Mines conducted a comprehensive study of the energy used in the asbestos mining industry in 1973. The survey covered all producers in Arizona, California, North Carolina, and Vermont. (See table 8.)

On a tonnage basis, energy used per ton of usable asbestos was 1,500 kilowatt-hours. Estimated cost was $1.7 million or $11.55 per ton.

OPERATING FACTORS AND PROBLEMS

In 1970, the Congress enacted "The Clean Air Act." Among the provisions of that act was that the administrator of the Environmental Protection Agency (EPA) could designate, when he felt it warranted, substances as "hazardous air pollutants." Among the three substances named to his first list on March 31, 1971 was "asbestos." This was the first Federal agency to give official credence to the growing worries about the effects of asbestos dust upon the health of humans. There was then, and is now, much controversy about this and similar actions of Federal, State, and local regulatory agencies.

There is insufficient space to document the many conflicting reports and insufficient data to assign validity or lack of validity to each. The areas of consensus are few and are as follows:

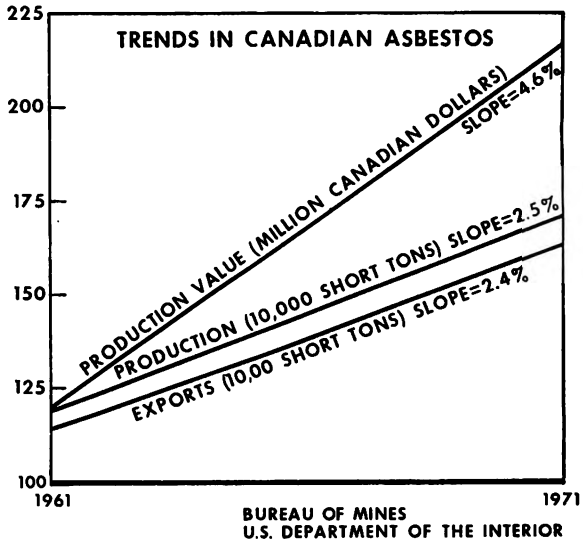


Figure 4.—Trends in Canadian asbestos production, exports, and production value, 1961–71.

1. Prolonged occupational exposure to heavy concentrations of asbestos dust, in the absence of personal protective devices, can measurably increase the chances of a person contracting the type of pneumonoconiosis called "asbestosis."

2. Exposure to asbestos may increase the chances of contracting the very rare type of cancer called mesothelioma.

3. Asbestos workers exposed to heavy concentrations of dust without respiratory protection, and who are also heavy smokers have increased chances of contracting lung cancer.

4. There is no evidence of any physiological effects from ingested asbestos.

There is no consensus about a threshold limit value of an acceptable concentration that would minimize danger from exposure or even a method of measuring it. EPA says there is no acceptable way to measure asbestos in the ambient air. The Occupational Safety and Health Administration (OSHA) of the Labor Department is using a membrane filter and microscopy method with a present standard of five fibers greater than 5 micrometers in length per milliliter of air. This is to be reduced to two fibers per milliliter in 1976. The Mining Enforcement and Safety Administration (MESA) is ambivalent. Their coal mine group uses the OSHA method, but a two-fiber level; whereas, their metal and nonmetal group uses a particle impingement method with a threshold limit value measured in million particles per cubic foot of air.

The controversial aspects of the matter appear to be of the long-lasting variety with no early solutions in sight. An example is the Reserve Mining Co. case, in which the company was sued

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Table 8.—Energy used by the U.S. asbestos mining industry, 1973

Source and unit	Used in mining	Used in milling	Total used	Total (thousand kilowatt-hours)
Heavy fuel oil ---- thousand gallons	852	1,345	2,197	96,358
Natural gas ---- million cubic feet	----	168	168	50,736
Electricity ---- thousand kilowatt-hours	2,641	44,974	47,615	47,615
Diesel oil ---- thousand gallons	412	133	545	22,147
LPG ---- do	14	168	182	6,987
Gasoline ---- do	52	12	64	2,343
Total energy ---- thousand kilowatt-hours	59,192	166,994	226,186	226,186

by the Federal Government, primarily for polluting Lake Superior with asbestos in the tailings dumped there, and secondarily for air pollution with asbestos fibers. The judgment rendered said there was no indication of harm from ingested asbestos but that both the water and air pollution must be abated in a reasonable time.

The controversy had no obvious effect in the market place in 1973 and 1974, in which years there were record high consumption and production. There were indications, however, that, as noted under "Resources," the small asbestos mining industry in the United States may not survive the added capital expenditures needed to meet environmental requirements.

Much research was funded by congress to answer environmental questions. Some of these as yet unanswered questions are as follows:

1. Is asbestos by and of itself a true carcinogen?
2. Are there significant differences, under the same conditions of exposure, between the toxicities of different types of asbestos?
3. What is the dose-response relationship to asbestos dust exposure, or what exactly is a safe level of exposure?
4. Are there any physiological effects from the asbestos in the ambient air?
5. Is there a valid correlation between measurements of asbestos dust by the various methods?
6. Is there any physiological effect from asbestos ingested with food or water?
7. Are there valid correlations between the health effects of no longer existent conditions of 30 years ago and those of today or between occupational and incidental exposure to asbestos?

The health problems allegedly connected with exposure to asbestos dust continue to make headlines. Stories about the dangers of asbestos dust from air ducts, brake linings, erection and demolition of buildings are just a few of the late ones. These stories, whether valid or not, keep pressure on the regulatory agencies and may be a causative factor in OSHA's late 1975 proposal to reduce the safe exposure level to asbestos from 5 fibers per cubic centimeter to 0.5 fibers/c.c.

OUTLOOK

Demand

Domestic demand for asbestos is expected to increase at a slow rate and to occur within the range of 1,012,000 to 1,812,000 short tons in the year 2000. The low of the range indicates an average annual growth rate of 0.9 percent; the high indicates 3.0 percent.

The forecast was derived by contingency forecasting of the major end-use demands considering possible shifts caused by either changing technology or dwindling resources during the forecast period. (See table 10.)

Much higher than normal growth in demand was experienced by asbestos in the decade between 1940 and 1950. The total increase was 200 percent above the 1940 level, half of it occurring during the war years and half in the following 5 years. Estimates of annual growth rates between 0.54 and 2.73 percent were obtained by least-squares regression analysis between asbestos demand and appropriate economic indicators. The quantity of asbestos indicated by this projection method for each end use was modified to obtain a demand range contingent on the occurrence of technologic or other changes in the consuming industries. About 70 percent of the asbestos demand in the United States during 1975 was consumed in new construction, and this use percentage is expected to persist throughout the forecast period.

The U.S. demand for asbestos in 2000 is expected to be about 1.25 times that of 1973. The rest-of-world demand should show a greater growth since the developing countries have a much greater new construction potential. The demand could increase at the same rate as gross national product (GNP), but it is likely to be limited by capacity to produce. This growth rate is estimated at 3.5 percent. Should the rest of the world be so beset with problems as to prevent an increase in general living standards, the expanded consumption of asbestos would be directly related to population, with an average growth rate estimated at 2.5 percent. The low of the range would be 7.3 million tons under these conditions. Table 9 summarizes the forecast

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Table 9.—Summary of forecasts of U.S. and rest-of-world asbestos demand, 1973–2000

(Thousand short tons)

	1973	2000 Forecast range		Probable		Probable average annual growth rate 1973–2000, percent
		Low	High	1985	2000	
United States:						
Total	876	1,012	1,812	930	1,114	[1] 1.2
Cumulative [1]	----	25,400	35,200	10,400	25,800	----
Rest of world:						
Total	3,725	7,256	10,741	5,629	9,430	3.5
Cumulative	----	145,000	182,000	56,300	169,000	----
World:						
Total	4,598	8,268	12,553	6,559	10,544	3.2
Cumulative	----	170,400	217,200	66,700	194,800	----

[1] Calculated from a 20-year U.S. demand trend of 804 for 1973.

ranges for both the United States and the rest of the world. Figure 5 shows historical demand in the last 20 years and 10- and 20-year trend projections to the year 2000.

Demand for asbestos for use in the construction industry was projected to the year 2000 at an average annual growth rate of 0.3 to 0.5 percent on the basis of total new construction modified by the 20-year trend, as determined by least-squares regression analysis. The figures for the year 2000 are believed to be near the minimum that could normally be expected. However, substitution is possible in many of the end uses, particularly in the asbestos cement products, where a variety of alternate ceramic and new plastic materials are available, and in paints and caulking where asbestos has a wide range of substitutes. The low end of the range for asbestos construction products was obtained by assuming a continuation of the 20-year trend.

On the high side of the demand range, the most apparent opportunities for increases above the forecast base appear to be the asbestos cement products, which compete with lumber and other building products, many of which are increasing rapidly in price. The growth rate for asbestos cement products could average 4 percent per year and approach the anticipated growth rate for total new construction by the year 2000. Use of asbestos in floor tile has been increasing in recent years because of shortages and higher prices for some competing materials. Paper products are used in electrical appliances as well as in construction, and although the quantity for such use is relatively small, it is expected to grow more than 1 percent per year.

Asbestos demand for friction products was projected to the year 2000 at an annual growth rate of 1.50 percent. This figure was based on a formula derived from least-squares regression analysis of total asbestos demand modified by the estimated growth in the automobile industry and economic indicators, which showed the best correlation.

Asbestos is an important part of many types of friction materials for use in automobiles, trucks, and other transportation equipment. Modern industry could scarcely function without asbestos friction materials. In addition to using asbestos in brake linings, today's motor cars, equipped with automatic transmissions, get their drive from metal transmission disks, which are covered with a super-tough paper containing crocidolite asbestos. The average automobile with power shift contains from 8 to 12 of the paper lined disks. Although the quantity of asbestos in each transmission is small, the output of more than 8 million automatic transmissions annually requires disk paper production in hundreds of tons.

A new composition disk-brake-shoe unit containing asbestos, designed to meet the critical braking requirements for the new 150-mile-per-hour passenger train systems has been developed.

Based on an estimated forecast of the number of motor vehicles produced in the year 2000, approximately double 1973 production, and on the assumption that the use of asbestos per vehicle will remain at present levels, the forecast for asbestos demand in user-operated vehicles is projected to 118,000 tons. An increased number of transportation vehicles and equipment using parts made of asbestos or maintaining the present quantity used per vehicle could result in a demand as high as 144,000 tons.

Demand for asbestos in textiles was projected to 21,000 tons in year 2000 by formula derived from least-squares regression analysis modified by the 20-year trend.

Asbestos textiles are used in the manufacture of yarn and cloth, which is used in products such as safety clothing, packings, brake linings, and filters. Carded fiber filters are 100 percent asbestos and are used for the clarification of such liquids as beer, wine, oils, and chemicals. Asbestos lap is a felted form of carded asbestos fiber made for the electric wire and cable industry, as insulation for heater cords, fixture wires, and other electrical conductors. Asbestos rovings are used by the electric wire industry to serve as insulation for heater cords, cables, and

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Table 10.—Projections and forecasts for U.S. asbestos demand by end use, 1973 and 2000

(Thousand short tons)

End use	1973	2000			
		Contingency forecasts for United States			
		Forecast base	Forecast range		Probable
			Low	High	
Asbestos cement pipe	166	475	178	479	190
Asbestos cement sheet	64	100	65	104	68
Flooring products	218	360	233	372	236
Roofing products	87	150	93	148	94
Packing and gaskets	26	75	64	75	66
Friction products	79	150	110	144	118
Insulation	26	30	30	39	34
Paper	18	45	21	40	27
Textiles	18	20	19	24	21
Other	174	400	199	387	260
Total	876	----	1,012	1,812	1,114

electrical-heating elements. The projected growth of asbestos demand in electrical appliances coupled with design improvements that increase asbestos use could result in increased asbestos demand. On the other hand, there are other materials used as insulation that could replace asbestos for some purposes.

Because of its inherent incombustibility and thermal stability, asbestos cloth is extensively used wherever these properties are essential in a fabric. Many Government specifications require pipe insulation to be protected by an outside jacket of asbestos cloth. Many maritime specifications and industrial and utility powerplants also require asbestos cloth to hold the insulation in place and to serve as a permanent protection and fireproof jacket over pipe and boiler insulation. Specially processed lint-free asbestos cloths also serve as protective shields in "clean" areas adjacent to nuclear reactors.

Competition from other substitute material is not likely to be important and no competitive factor is considered. Production of asbestos textile yard, cord, and thread in 1963 was 19.7 million pounds and is assumed to be nearly the same now. Output of asbestos cloth in 1963 was 9.4 million pounds and 11.5 million pounds in 1968. Data for the last 5-year period (1968–73) are not available. Assuming that there will be some increased use of asbestos for such items as electrical appliances and fire-fighting equipment, the high projected demand could be perhaps 24,000 tons in the year 2000.

On the basis of past performance, it is likely that new uses for asbestos will be forthcoming, and the forecast base of 260,000 tons in the year 2000 was obtained by correlation with the projected growth for GNP and effects of regrouping end uses. With low cost, short fiber available from domestic sources in large quantities there should be a significant impact on the mineral filler market

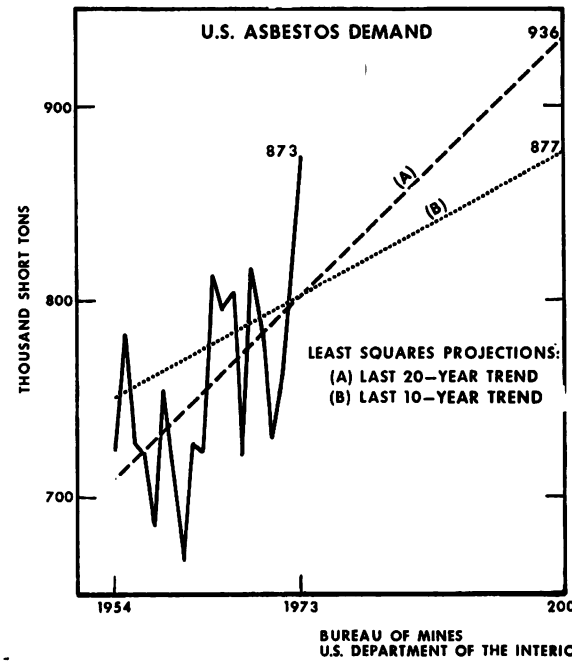


Figure 5.—U.S. asbestos demand, and projected trends to 2000.

for a wide range of end products, particularly in products that must withstand high temperatures or corrosive conditions.

Supply

Domestic resources of chrysotile are found mostly in California, Vermont, and Arizona. Although deposits are known to exist also in Montana, Oregon, Wyoming, and a few other States, production from these has been negligible. California has the greatest potential of becoming a substantial producer of short fiber asbestos. In addition, anthophyllite asbestos is produced in North Carolina.

An EPA report (*12*) shows that nine of the major asbestos products manufacturing firms have captive fiber sources through U.S. and Canadian mines, either wholly or partially owned. The total present production capacity of these mines exceeds 2 million short tons per year.

The United States has been dependent on foreign supplies of asbestos for certain essential and strategic grades in the necessary quantities for times of emergency. Canada supplies most of our requirements for chrysotile while amosite and crocidolite originate in the Republic of South Africa. World expansion and increasing demands indicate a possible inadequacy of foreign supplies, thus encouraging the development and production of domestic resources. Such development of domestic asbestos deposits, if

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feasible under environmental regulations and coupled with advancing technology in the use of substitutes, could shift our position from heavy reliance on foreign supplies for this mineral.

United States and Canadian chrysotile resources are more than ample to meet the high of the forecast domestic demand for 2000, but could affect Canadian capability for supplying a major part of the demand in the rest of the world.

The relatively small requirements for amosite asbestos will continue to come from the Republic of South Africa unless deposits of this variety of asbestos are discovered in other countries, or unless adequate substitutes become available at competitive prices, thereby providing acceptable options to the consumers. Crocidolite asbestos will also be obtained from the Republic of South Africa, and perhaps from Australia or Bolivia so long as it remains competitive with chrysotile, but substitution is practicable in end uses, and continuation of crocidolite supply is not particularly significant.

Demand for asbestos in the United States for domestic consumption in 1973 was 876,000 tons, about 15 percent of which came from domestic sources, most of the balance was obtained from Canada and the Republic of South Africa. Annual requirements for asbestos in the year 2000 are not expected to exceed 1.8 million tons, the high of the forecast range shown in table 9. If the 1973 ratio of domestic production to demand prevails in the year 2000, the domestic production component required to meet the maximum expected demand would be 308,000 tons at about $37.6 million at the 1973 average price. This production could be accomplished from known resources only by much more extensive use of the low-cost, very-short-fiber Coalinga, Calif., material than prevails at present. Historical and projected domestic production and demand for asbestos are shown in table 11. The trend projections for demand are low compared with the forecast range, caused mainly by the time periods chosen for the trend projections. Based on the last 20-year period, the demand growth for asbestos has averaged about 1.0 percent per year from 1954 to 1973, and 0.4 percent per year from 1955 to 1974.

Table 11.—Comparison of domestic asbestos production and demand 1954–74 and projected production in 2000 based upon historical trends

(Thousand short tons)

Year	U.S. demand	Domestic production	
1954	724	46	
1955	782	45	
1956	728	42	
1957	724	43	
1958	685	44	
1959	754	46	
1960	709	45	
1961	666	53	
1962	726	53	
1963	724	66	
1964	813	101	
1965	795	118	
1966	805	126	
1967	721	123	
1968	817	121	
1969	784	126	
1970	734	125	
1971	759	131	
1972	809	132	
1973	876	150	
1974	846	113	
1985	[1] 930	[2] 211	[e]160
2000	[1] 1,114	[2] 323	[e]200

[e] Estimated.
[1] Probable forecasts from table 9.
[2] 20-year trend.

Possible Technological Progress

Although asbestos synthesis was accomplished in the late 1920's, and much work has been done since that time, an economical method of synthesis has not yet been announced. Technology must come up with competitive synthetic asbestos or asbestiform products and make them available in significant quantities before the end of the century for demand to be met. The mineral raw materials needed for production of synthetic asbestos and other inorganic fibers are abundant.

Among the factors that should tend to increase asbestos demand within the next decade is the newly developed potential for large-scale production of low-priced asbestos from domestic deposits, which should in time spur research into new uses and into new ways to substitute short-fiber asbestos for the longer, more expensive types. The domestic product is being used in asbestos cement pipe and undoubtedly can be used in other products by adapting the production processes.

Work is underway which is aimed at developing large-scale asbestos uses. Foremost among these is the potential for use in asphalt paving materials, which must bear up under various difficult conditions. Examples are airport runways and hangar areas, which are subjected to high-temperature, corrosive effects of jet exhausts; street curbing, which must be able to absorb shock and forces from the wheels of motor vehicles; and resurfacing of old roads. The latter use requires about 35 tons of asbestos per mile of 40-foot pavement and probably has the greatest potential for large-volume asbestos requirements. Technological changes in road-building methods could result in capping of new highways with asbestos-rich asphalt.

Medical problems connected with asbestos have been under intense study in recent years and undoubtedly will continue to warrant increasing attention in the future. In addition to study and medical treatment of the effects of

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asbestos on the respiratory system, work should be aimed at improved methods for protecting workers in mines, mills, and fabricating plants. Among the possibilities for solving the problems, in addition to medical study and treatment, are much greater use of automation where feasible, remote control of fabrication processes, improved protective equipment and respiratory devices, and development and strict enforcement of safety procedures.

Remaining Problems

One of the most serious problems confronting the domestic consuming industry is our dependence for the greater part of our supply of asbestos on foreign sources. About 85 percent of the supply of chrysotile and all of the amosite and crocidolite comes from foreign countries. Complete dependence upon foreign supply for strategic grades can be minimized by adequate stockpiles.

Adequate information on the methods of mining and processing of asbestos and development of equipment is available, but cost data are lacking. Information is available on the principal end products in which asbestos is utilized; however, there is no information on the wastage that takes place in the manufacturing of the end item.

The number of materials that are economically competitive with asbestos are limited. While much research has been directed to synthesizing fibers that have properties similar to asbestos, it has met with only limited success. The development of practical technologic advances in this broad area would substantially improve the supply outlook.

Health hazards are present in the whole sequence of mining, processing, and utilizing asbestos, and the expanding use of this material demands continued attention to the problem.

Asbestos is not an energy-intensive mineral; to the contrary, it has a long association with energy conservation products. Nonetheless, energy conservation practices need further development in all phases of the mining, milling, and utilization of asbestos.

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