THE UNION CARBIDE "CALIDRIA" ASBESTOS BUSINESS

(J. L. Myers 5/1/79, Rev. 7/11/79)

In 1957 a Union Carbide exploration geologist was in central California looking for nickel or other metallic mineral deposits which could be of value to the Corporation. He took note of a peculiar white, leathery mineral which was eventually determined to be chrysotile asbestos in a unique physical form. Exploration activities were centered in the nearly town of Coalinga, and the deposits have become known as Coalinga Asbestos.

Asbestos (from a Greek word meaning non-burning) is a commercial term applied to several fibrous metal silicate minerals which are fire-proof and capable of being processed into flexible fibers. There are six varieties of asbestos which are divided into two groups, serpentine and amphibole, based on their crystal structure (Att. 1). Chrysotile is the only member of the serpentine group while the amphiboles include crocidolite, amosite, anthophyllite, tremolite and actinolite.

Chrysotile accounts for over 95% of world consumption; and, of the amphiboles, only crocidolite and amosite have any commercial significance. Sources and general uses of the three varieties are shown in Att. 2; and Att. 3 summarizes comparative data for them.

Based on epidemiological and other data, many medical and scientific authorities agree that crocidolite and amosite are more harmful to human health than chrysotile. Although U.S. regulations do not reflect this, the UK and other countries have severely restricted the use of crocidolite and amosite.

Chrysotile has several characteristics which are responsible for its widespread usage in over 3000 applications: worldwide availability, positive surface charge, flexibility, softness, high tensile strength (see Att. 4). Chrysotile occurs only in serpentine (California's official State Rock), which is a fine-grain rock composed almost entirely of hydrous magnesium silicate minerals similar to chrysotile in composition. Canada is the free world's largest producer of chrysotile asbestos, and supplies about 90% of the U.S. asbestos requirements.

The Canadian and most other deposits of serpentine contain chrysotile in cross-fiber veins that are rarely more than half an inch thick. A typical ore contains only 6-10% fiber, of random lengths and tightly bonded together in a parallel configuration (see Att. 5). The Coalinga Asbestos deposit bears little resemblance to other serpentine bodies found throughout the world since most of the mass has been highly sheared and pulverized by nature. It consists of soft, friable sheets and clumps of asbestos fibers, and the only other known ore body of this type is the Stragari deposit in Yugoslavia. In contrast to the cross-fiber arrangement of conventional ores, the Coalinga deposit occurs as a swirling mesh of disoriented fibers (see Att. 6). Each fiber or fiber bundle is only in point contact with its neighbor, and the fiber content ranges from 50-60%.

The Coalinga deposit is located in the southern part of the Diablo Mountain range, in Fresno and San Benito Counties (see Att. 7). It is in what is known

as the New Idria mining district, which has long been famous as the oldest producing mercury mine (since 1853) in the United States, and is thought to be the largest single mineral deposit in the world. (Union Carbide's trade-name "CALIDRIA" is a combination of "CAL" from California and "IDRIA" from New Idria.) Rich asbestos ore has been found over an area of 40-50 square miles, and to depths of over 500 feet. Conservative estimates indicate that over one hundred million tons of Chrysotile asbestos are available, while Canada's ore reserves have been estimated at less than 50 million tons.

In addition to having a very low fiber content, Canadian ore deposits contain fibers of various lengths, from a few microns up to several inches. These are defined by Canadian screening tests and designated as Grades 3 through 7 (see Att. 8). Conventional Canadian processing techniques include blasting, crushing, grinding and air classifying. A typical Canadian Grade 7 product will contain about 30-40% serpentine rock dust and 60-70% asbestos fibers. Most of the fibers will still be in bundles as shown in Att. 9.

Union Carbide mines the Coalinga ore by conventional open pit methods (see Att. 10). After removing 20 feet or less of overburden, ripper-equipped bull-dozers and self-propelled scrapers are used to remove ore from the deposit. Before hauling the ore 55 miles to the plant near King City, it is screened to minus 3/4-inch. Mining operations are carried out every other year during the dry season (May to October), and ore is delivered to the plant every year during this same period. Mining and hauling are sub-contracted, but supervised by plant personnel.

Union Carbide evaluated various dry processing methods but the best product looked little different than that depicted in Att. 9, and performed very similar to Canadian asbestos. An investment to produce such a product for conventional asbestos applications was not justified. In order to take full advantage of the unique features of the Coalinga ore deposit (summarized in Att. 11), a hydraulic beneficiation process was developed. Conventional mineral processing techniques were combined with the innovative use of special equipment and a plant was designed with three basic systems: rock fiber separation, refining, and special treatment (see Att. 12). This enables production of three basic product categories: fiber, colloidal, and modified, all with liberated fibers as shown in Att. 13.

The semi-works plant (see Att. 14) was started in 1963 and was expanded to its present capacity, except for RG-244, in 1966. The asbestos business was in the Nuclear Division until 1965 when it was transferred to the Metals Division. In an attempt to achieve better market compatibility, and hopefully increased sales, the business was transferred to the Chemicals and Plastics Division (Group I) in 1967. RG-244 was introduced in 1968; and, because of lack of sales growth and no apparent upper management interest, the asbestos business was put up for sale in 1969. It should be noted that considerable losses had been experienced since startup and negative net income was shown through 1970. The asbestos business has never had a good "fit" in the Corporation and probably never will have unless other non-metallic minerals can be developed and marketed by the same group as a separate entity or department.

The business was not sold but it was transferred back to the Metals Division in 1970; and, in 1971, the first positive net income was realized. During 1970 the marketing philosophy was changed from trying to develop new products and

markets, to selling existing products to conventional asbestos markets and spending a minimum amount of resources on development. Personnel who had been with the business for several years in production and technical capacities were transformed into a sales group which also performed technical and marketing service functions. This group is essentially still intact and the financial performance of the business for the last seven years is shown in Att. 15. A historical summary of the asbestos business is shown in Att. 16.

Although, on paper, the asbestos business conforms to the regular organization of the Metals Division, there are some aspects which, in reality, are considerably different when compared to other Division product lines. There are basically two groups which operate the business: plant production and product marketing. In addition to production, plant personnel also handle order entry, invoicing, shipments (domestic and foreign), inventory control, warehousing and associated responsibilities. In addition to direct sales, marketing personnel handle technical service, orders, health and regulatory matters, product and market development, sales promotion and literature development, international sales and other associated responsibilities which are normally handled by special departments within the Division. There is very close cooperation between plant and marketing personnel with little involvement by New York management. There is obviously some concern over this type of operation but a small business, such as asbestos, can be operated successfully in this manner. (Plant and Marketing organization charts are shown on Att. 17 and 18.)

Union Carbide's asbestos business involves the mining, milling and production of short fiber, high quality asbestos fiber products for world-wide marketing into relatively small segments of various industries. Major tonnage sales are to the vinyl-asbestos floor tile industry and similar applications for short fiber asbestos. "Calidria" asbestos does not compete with non-short fiber asbestos in other markets, which comprise the major share of the asbestos industry. Major dollar sales of our asbestos business are from viscosity control markets where the competition is non-asbestos products. Again, "Calidria" asbestos does not compete with these non-asbestos products in the major share of their markets.

As mentioned earlier, asbestos, especially chrysotile, is mined and produced throughout the world. Att. 19 summarizes the major sources of asbestos.

Apparent consumption of chrysotile asbestos in the U.S. has dropped from a peak of 876,000 tons in 1973 to an estimated 641,000 tons in 1978. Union Carbide is responsible for about 25% of U.S. production and supplies about 3% of total U.S. comsumption (see Att. 20). According to USBM estimates, UCC was responsible for 36% of U.S. production in 1978 and provided 4.1% of total U.S. consumption.

Based on preliminary estimate for 1978, chrysotile was used in the U.S. as shown in Att. 21. This was a typical year and shows that the construction industry continues to use about 63% of the total consumption. The markets in which we are able to at least partially compete with Canadian asbestos are marked and total about 282,000 tons.

Attachment 22 summarizes the domestic applications for various "Calidria" products. As shown in Att. 23, the asbestos industry consumes 95% of tons and

65% of dollars, while the non-asbestos industry consumes only 5% of tons but provides 35% of sales dollars.

Attachments 24-32 describe how "Calidria" asbestos fits into the potential domestic asbestos and non-asbestos markets as previously described.

ATT. 1

ASBESTOS - HYDRATED METAL SILICATE

SERPENTINE

CHRYSOTILE

AMPHIBOLE

CROCIDOLITE

AMOSITE

ANTHOPHYLLITE

TREMOLITE

ACTINOLITE

A03558

ATT. 2

GENERAL ASBESTOS INFORMATION - U.S.

	Major Sources	Applications	1978 Estimated U.S. Consumption
Chrysotile	U.S., Canada	cement, tile, friction materials, textiles, plastics, insulation, asphaltics	632,000 T
Crocidolite	So. Africa	reinforcing, insulation	16,500 T
Amosite	So. Africa	insulation, packings	1,500 T
		TOTAL	641,000 T

A0355

COMPARATIVE DATA FOR ASBESTOS MINERALS

	CHRYSOTILE	CROCIDOLITE	AMOSITE
FORMULA	$3MgO \cdot 2SiO_2 \cdot 2H_2O$	$Na_2O \cdot Fe_2O_3 \cdot 3FeO \cdot 8SiO_2 \cdot H_2O$	$1.5MgO \cdot 5.5FeO \cdot 8SiO_2 \cdot H_2O$
COMPOSITION,%			
SiO_2	37-44	49-53	49-53
MgO	39-44	0-3	1-7
FeO	0-6	13-20	34-44
Fe_2O_3	0-5	17-20	-
Al_2O_3	0-2	-	2-9
H_2O	12-15	2-5	2-5
CaO	0-5	-	-
Na_2O	-	4-8	-
$CaO+Na_2O$	-	-	0-3
CRYSTALS	FINE FIBERS	BRITTLE FIBERS	PRISMATIC CRYSTALS
COLOR	GRAY/GREEN	BLUE	GRAY/BROWN
TEXTURE	SOFT/SILKY	HARSH	HARSH
FLEXIBILITY	VERY GOOD	GOOD	GOOD
HARDNESS,Mohs	2.5-4	4	5.5-6
FIBER DIA., $^{\circ}A$	180-300	600-900	600-900
TENSILE, Mpsi	800	600	200
SURFACE CHG.	POSITIVE	NEGATIVE	NEGATIVE
RES. TO ACID	POOR	GOOD	GOOD
RES. TO ALK.	GOOD	GOOD	FAIR

SOURCE: MODERN PLASTICS ENCYCLOPEDIA (1972-3), AND ENCYCLOPEDIA OF CHEMICAL TECHNOLOGY, VOLUME 2, P. 136 (1948).

403560

ATT. 4

ADVANTAGES OF CHRYSOTILE FIBER

Worldwide Availability

Positive Surface Charge

Flexibility

High Tensile Strength

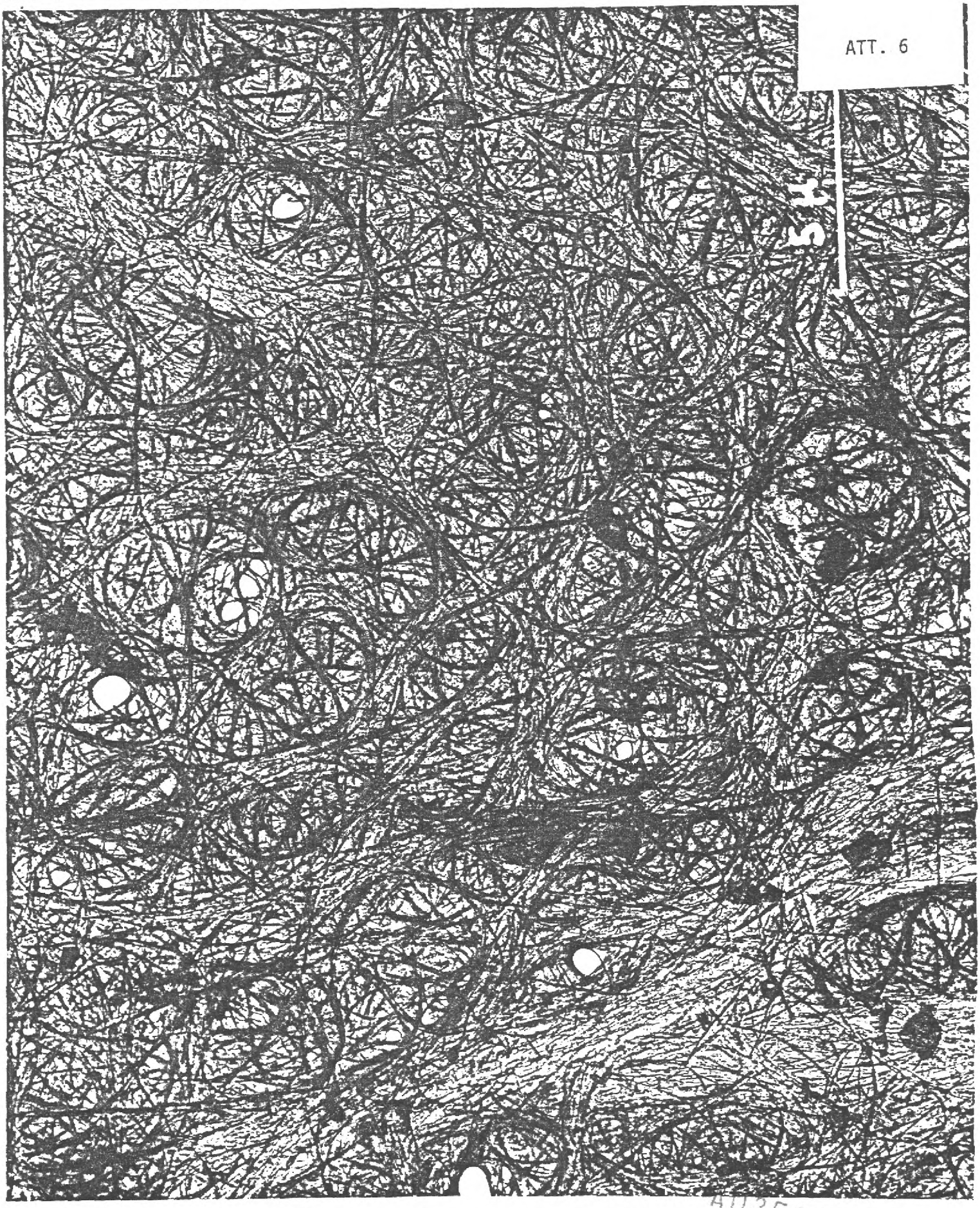
Softness

A03561

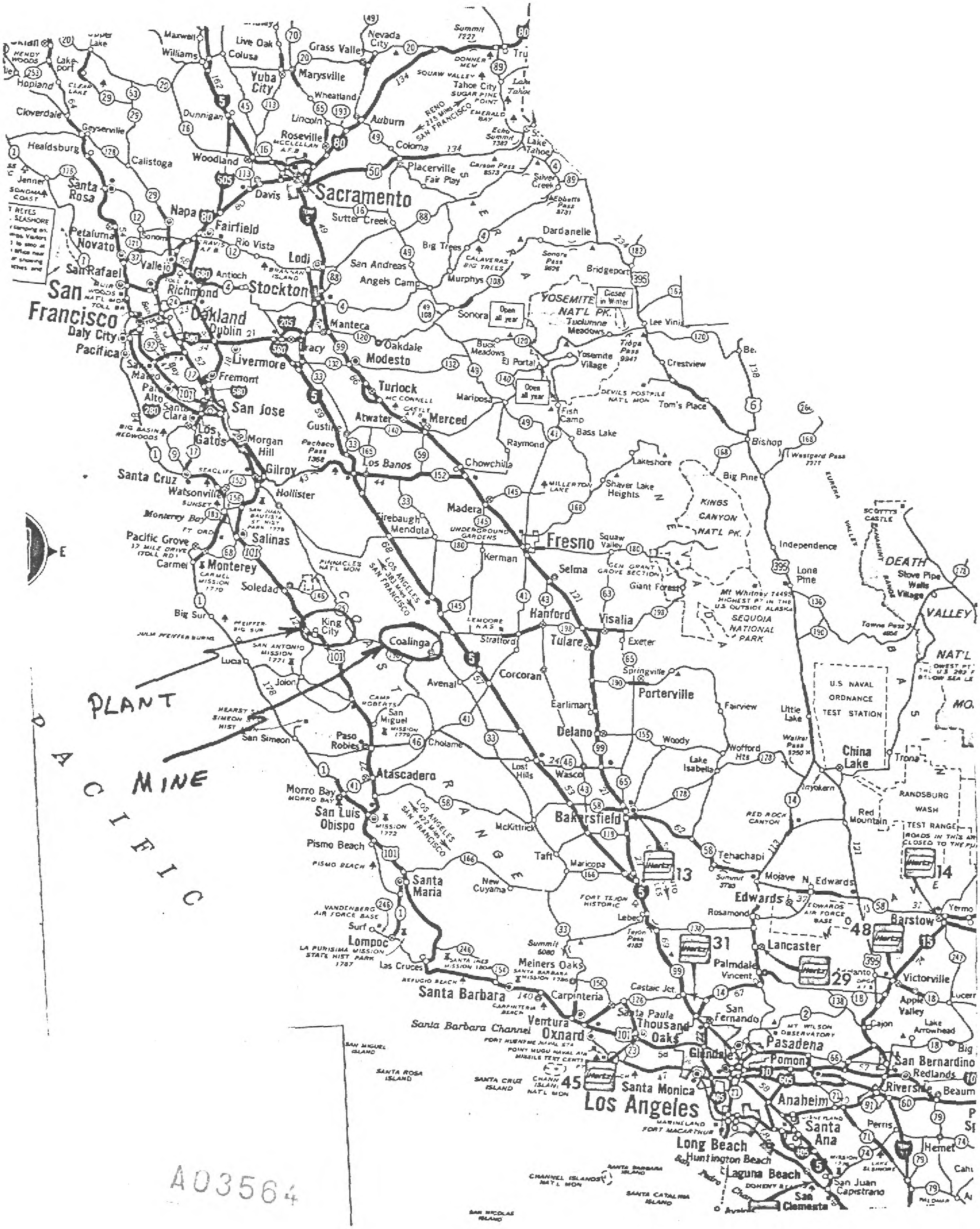
ATT. 5

A03562

UCC 008883



AU3563


PLANT
MINE
PACIFIC
King City
Coalinga
Sacramento
San Francisco
Oakland
Stockton
San Jose
Fresno
Modesto
Merced
Salinas
Monterey
Santa Cruz
Hanford
Visalia
Bakersfield
San Luis Obispo
Santa Maria
Santa Barbara
Los Angeles
Long Beach
Pasadena
Anaheim
Santa Ana
San Bernardino
Riverside
Lancaster
Barstow
Oxnard
Ventura
DEATH VALLEY
KINGS CANYON NAT'L PK.
SEQUOIA NATIONAL PARK
YOSEMITE NAT'L PK.

A03564

Canadian Chrysotile Asbestos Classification

Standard Designation Of Grade	Guaranteed Minimum Shipping Test* ½" Mesh	4 Mesh	10 Mesh	Pan	Group Number
3F	10.5	3.9	1.3	0.3	Group 3 (Spinning Fibre)
3K	7	7	1.5	0.5	
3R	4	7	4	1	
3T	2	8	4	2	
3Z	1	9	4	2	
4A	0	8	6	2	Group 4 (Shingle Fibre)
4D	0	7	6	3	
4K	0	4	9	3	
4M	0	4	8	4	
4T	0	2	10	4	
4Z	0	1.5	9.5	5	
5D	0	0.5	10.5	5	Group 5 (Paper Fibre)
5K	0	0	12	4	
5M	0	0	11	5	
5R	0	0	10	6	
6D	0	0	7	9	Group 6 (Waste)
7D	0	0	5	11	Group 7 (Shorts)
7F	0	0	4	12	
7H	0	0	3	13	
7K	0	0	2	14	
7M	0	0	1	15	
7R	0	0	0	16	
7T	0	0	0	16	
7RF (Floats)	No Test				
7TF (Floats)	No Test				
8S	No Test				

*Guaranteed minimum shipping test is that test below which the actual shipping test shall not fall. The shipping test is the average for each carload or smaller shipment of tests of representative samples taken at time of shipment.

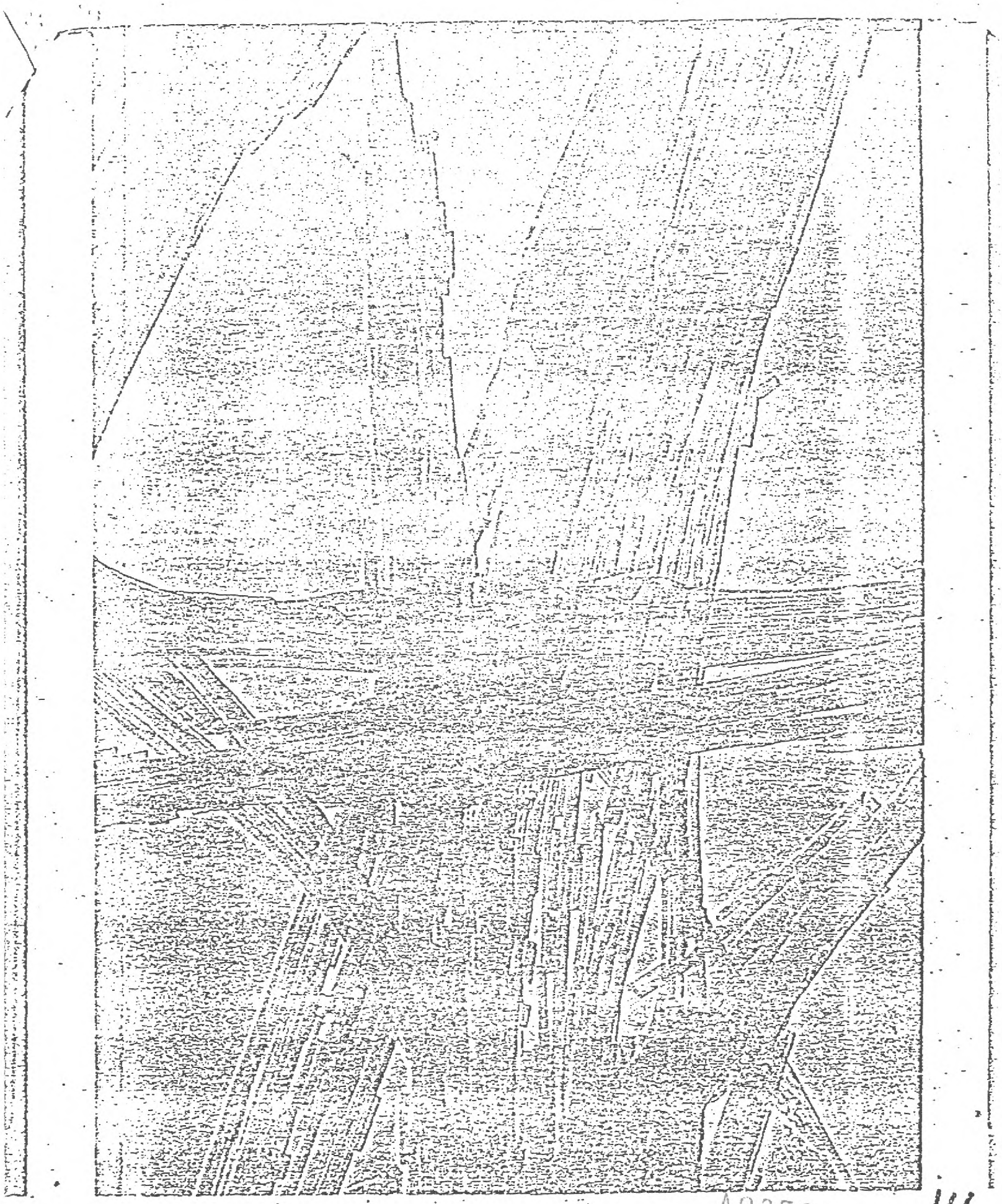
Uses of Asbestos with Corresponding Recommended Carey Grades

Canadian Chrysotile Asbestos is an essential raw material for a wide variety of products. To meet the requirements of specific industries, sub-grades, or grades within grades, have been developed by research. Grades are divided into sub-grades according to fibre length, degree of "crudiness" and amount or size of fines. Variations of this combination can change such characteristics as density, absorption, wet volume and setting rate. Carey Canadian produces a wide range of sub-grades as shown in the table below.

Important Products Containting Asbestos	*Recommended Carey-Canadian Grades**
Acoustical Plaster	6D-1, 7D-3, 7MS-1, 7M-5
Adhesives	7R-3, 7T-5, 7RF-9, 7TF-8
Asbestos Cement Products	4K-1, 4T-1, 5D-1, 5K-1, 5R-1, 5R-5, 6D-1, 6D-5
Asbestos Millboard	4T-1, 5D-1, 5K-1, 5R-1, 6D-1, 7D-3, 7M-5
Asbestos Paper and Felt	5D-1, 5K-1, 5R-1, 6D-1, 6D-01, 7D-3, 7M-5
Asphalt Compounds	7D-1, 7F, 7K3, 7KS-1, 7MS-1, 7M-5, 7RS-1, 7R-3, 7TS-1, 7T-5, 7RF-9, 7TF-8
Caulking and Sealers	7D-3, 7F, 7K-3, 7MS-1, 7M-5, 7RS-1, 7R-3, 7TS-1, 7T-5, 7RF-9, 7RF-10, 7TF-8
Cements	
Dry Wall Joint	7RF-9, 7RF-10, 7TF-8, 7TF-12
Fireproofing	5D-1, 5R-1, 6D-1, 7D-3, 7MS-1
Insulation Finishing	6D-1, 7D-3, 7M-5, 7M-90, 7T5,
Refractory	5R-1, 6D-1, 7M-5, 7M-90, 7MS-1
Fibrated Greases	7F, 7RF-9, 7RF-10

Important Products Containting Asbestos	*Recommended Carey-Canadian Grades**
Floor Tiles	
Asphalt	7R-3, 7RS-3
Vinyl Asbestos	7R-3
Rubber	7R-3, 7T5
Friction Material	5K-1, 5R-1, 5R-5, 6D-1, 6D-5, 7D-3, 7D-5, 7F, 7K-3, 7MS-1, 7M-5
Magnesite Flooring	7T-5, 7RF-9
Oil Well Muds	7R-3, 7RF-9
Pipe-fibre	7M-5, 7R-3
Plastics	
Cold Molded	5R-1, 6D-1, 7D-3, 7M-5, 7T-5, 7RF-9
Molding Compounds	7RF-9, 7TF-8, 7TF-12
Pre-mix Molding	7T5, 7TF-8
Radiator Sealing Compounds	7M-5, 7T-5, 7RF-9
Sheet Packing	4K-1, 4T-1, 5D-1, 5K-1, 5R-1, 5R-01, 6D-1
Textiles	3T-1, 4K-1
Welding Rods	7M-5, 7R-3, 7T-5, 7RF-9

*Sub-grade designations for all grades except Shorts indicate: (-1) well-opened, (-5) semi-crudy. Sub-grade designations for Short grades indicate: (-1) high bulk and oil absorption, (-3) (-5) (-9) (-10 (medium bulk and oil absorption, (-8) (-90) low bulk and oil absorption

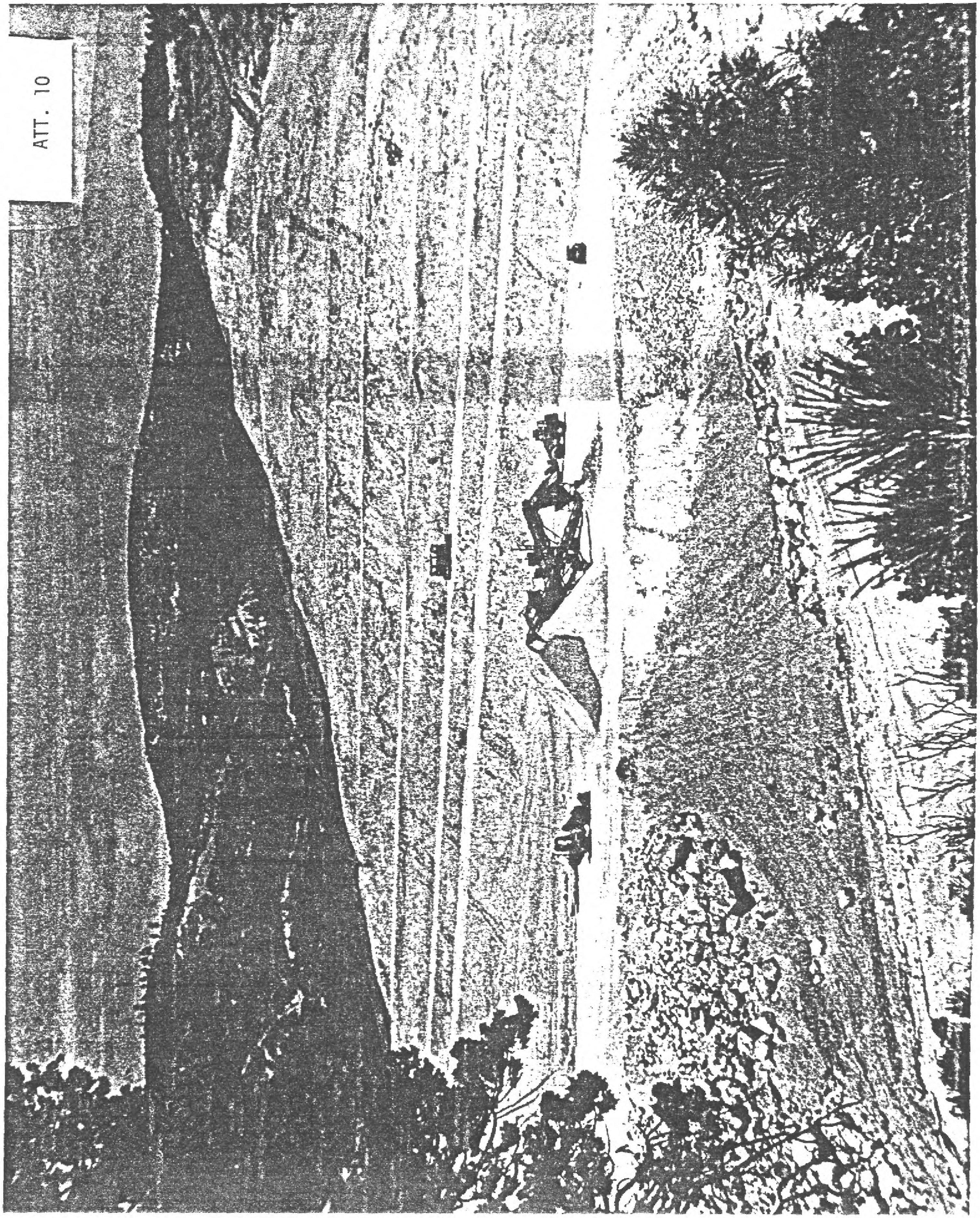


A03566

14

A03567

ATT. 10



UNIQUE CHARACTERISTICS OF THE COALINGA ORE DEPOSIT

All Chrysotile

All Short Fiber

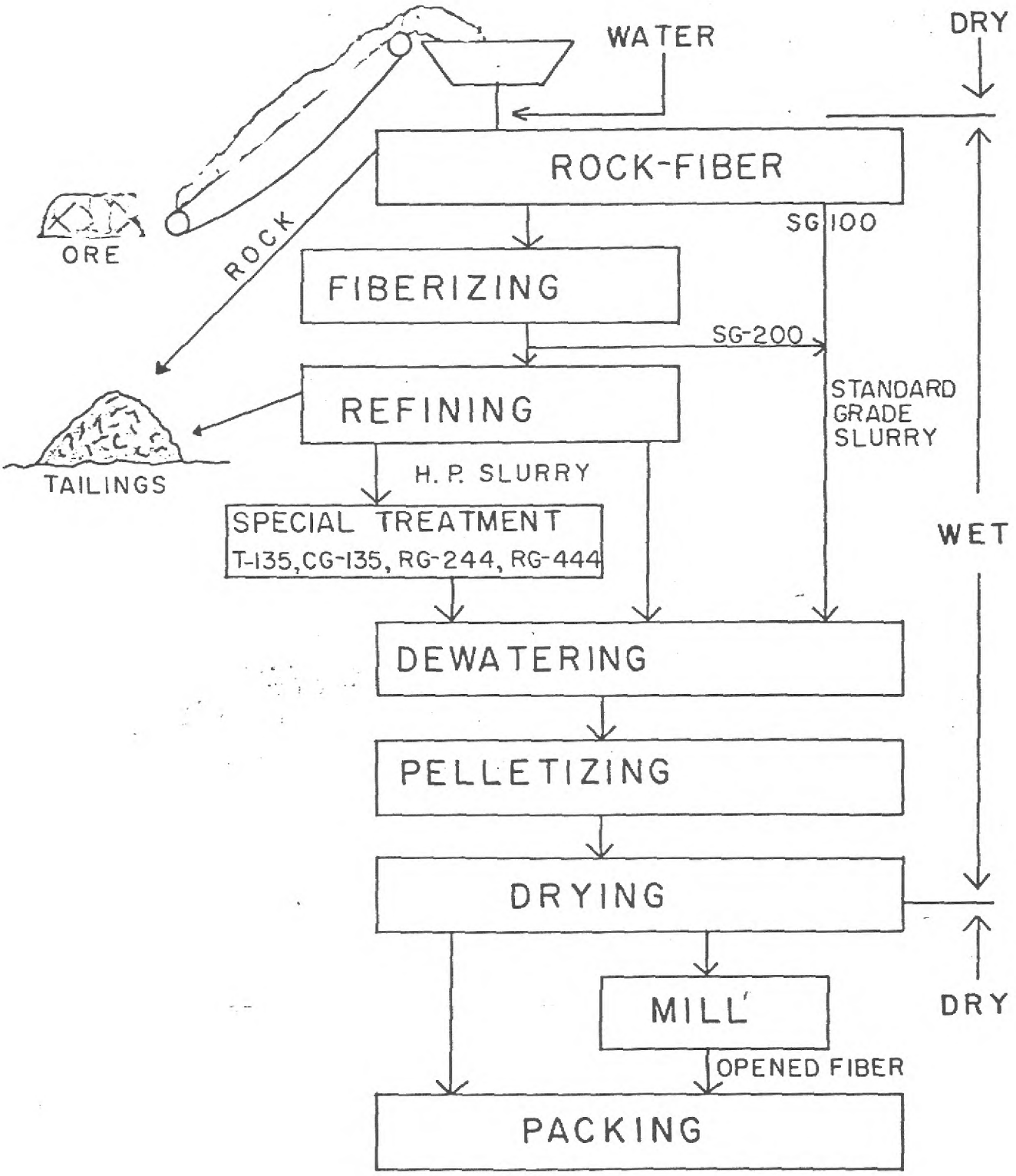
Random-Oriented Fibers

Over 50% Fiber

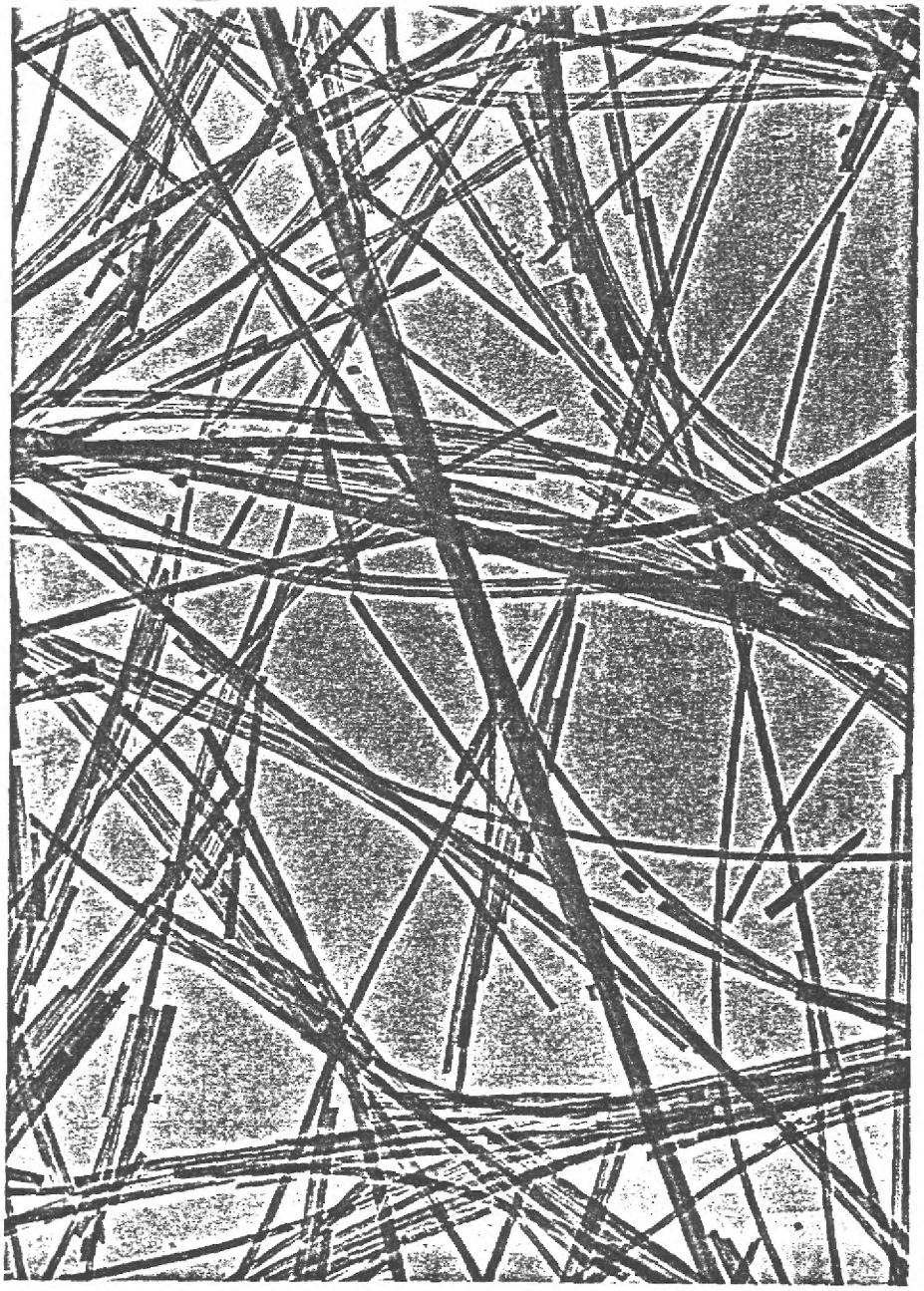
15-20% Moisture

Easy to Mine

CALIDRIA ASBESTOS PRODUCTION

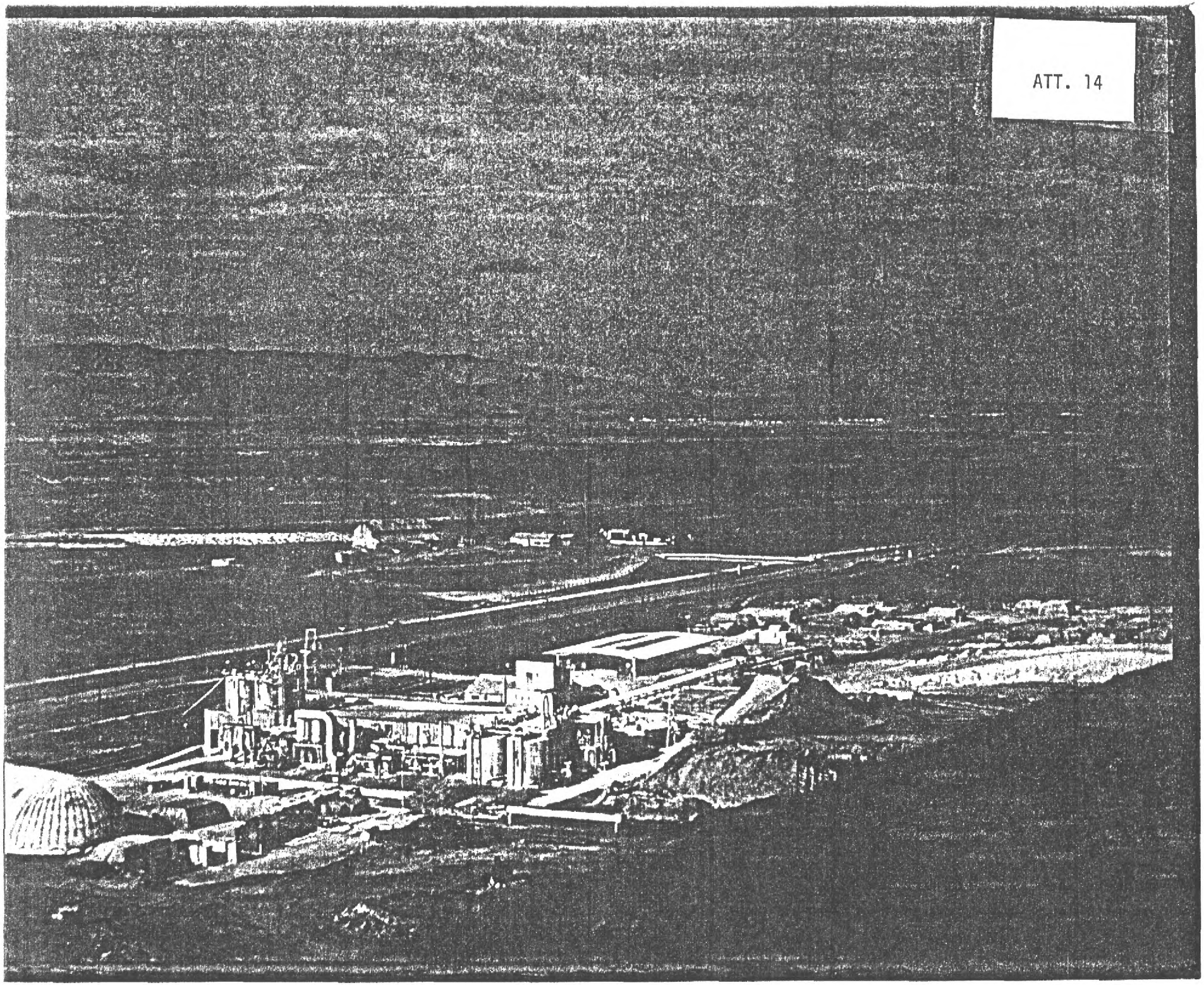


A03569



ATT. 13

A03570



ATT. 15

"CALIDRIA" ASBESTOS SALES & FINANCIAL SUMMARY

(JLM 5/1/79)

	1972	1973	1974	1975	1976	1977	1978	1979 Budget	1979 Fsct. II
Domestic Sales, $M	2127	2691	2483	3432	3085	3295	4566	4200	4186
Export Sales, $M	503	1112	1278	910	1774	2005	2590	2400	2846
Total Sales, $M	3043	3802	3761	4342	4859	5300	7156	6600	7032
Total Sales, Tons	21786	30724	25767	30081	24555	24891	35198	31210	31380
Plant Cost & Distr, $M	1802	2414	2604	2977	2920	3252	4212	4400	4228
Gross Margin, $M	828	1389	1157	1365	1939	2048	2944	2200	2804
Selling Costs, $M	429	494	574	640	679	733	715	676	711
Total O'Head, $M	555	844	871	960	1074	1066	997	1000	1020
Oper. Income, $M	273	545	286	405	865	982	1947	900	1784
Net Income, $M	79	342	87	73	458	631	1190	600	958
Earnings, ¢/Share	0.09	0.57	0.14	0.22	0.80	1.00	1.9	0.9	1.4
% ROA	--	11.4	2.6	2.9	10.5	12.8	25.4	12.1	18.2
Cash Generated, $M	(130)	(117)	(721)	176	122	1100	1035	600	1200
Product Value, $/T	140	124	146	144	198	213	203	211	224
Product Cost, $/T	83	79	101	99	119	131	120	141	135

ATT. 16

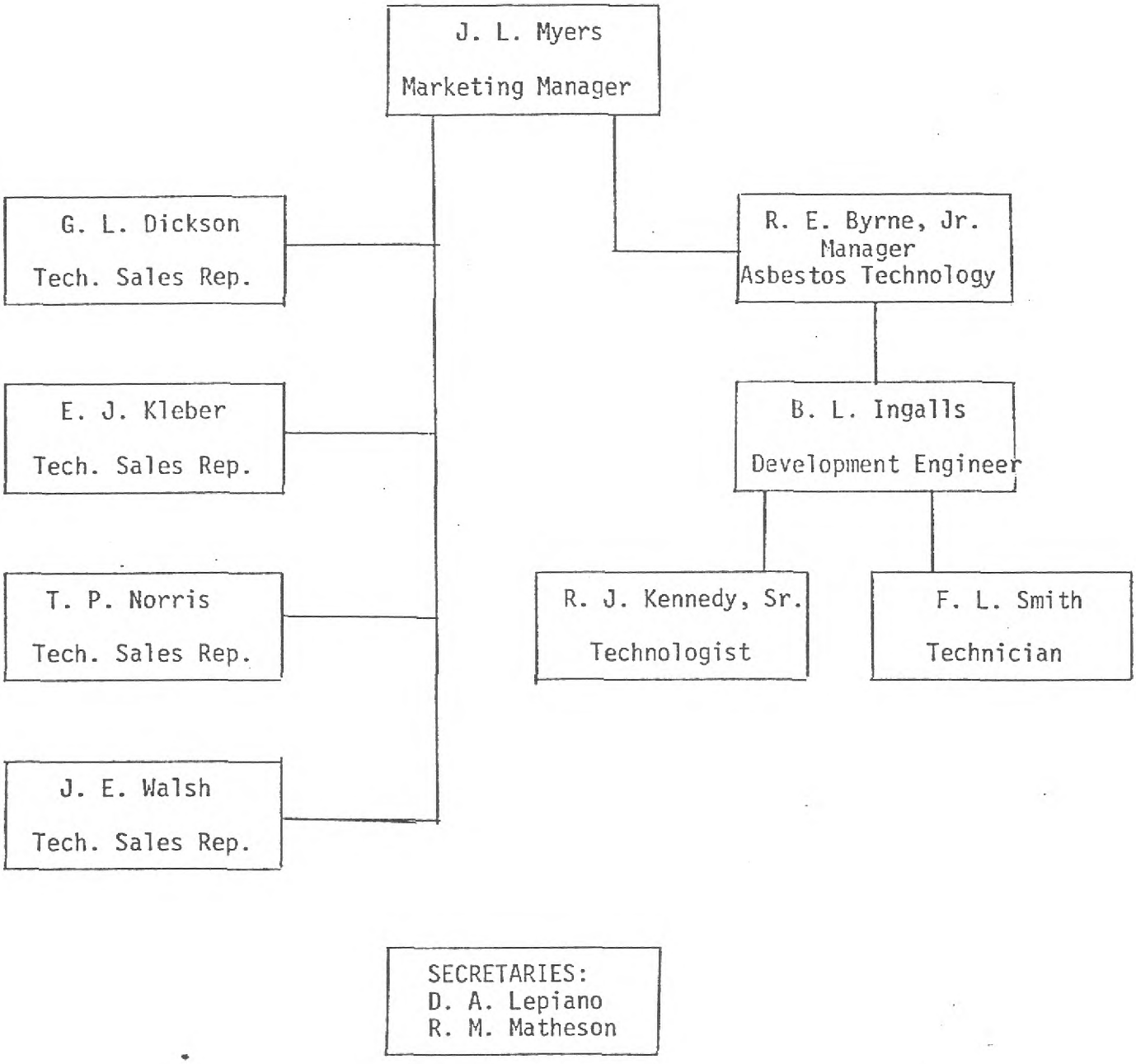
"CALIDRIA" CHRONOLOGY

1957	MINE DISCOVERED (NUCLEAR DIV.)
8/63	SEMI-WORKS PLANT STARTED
1965	TO METALS DIVISION
1/66	PLANT EXPANDED
1966	SALES OVER ONE MILLION DOLLARS
1/67	BUSINESS TRANSFERRED TO GROUP 1
2/68	INTRODUCED RG-244
1969	BUSINESS FOR SALE
1/70	BUSINESS TRANSFERRED TO METALS
1970	SALES ALMOST TWO MILLION DOLLARS
1971	FIRST POSITIVE NET INCOME
1972	SALES NEAR PLANT CAPACITY, OVER 3 MILLION DOLLARS
1973	SALES ALMOST 4 MILLION DOLLARS
5/74	INTRODUCED RG-600
1975	PLANT ON 21 SHIFTS/WK., SALES OVER 4 MILLION DOLLARS FIRST POSITIVE CASH FLOW
1976	SALES ALMOST 5 MILLION DOLLARS
1977	SALES OVER 5 MILLION DOLLARS, CASH FLOW OVER 1 MILLION DOLLARS
1978	SALES OVER 7 MILLION DOLLARS, RECORD PRODUCTION AND EARNINGS

A03573

ATT. 17

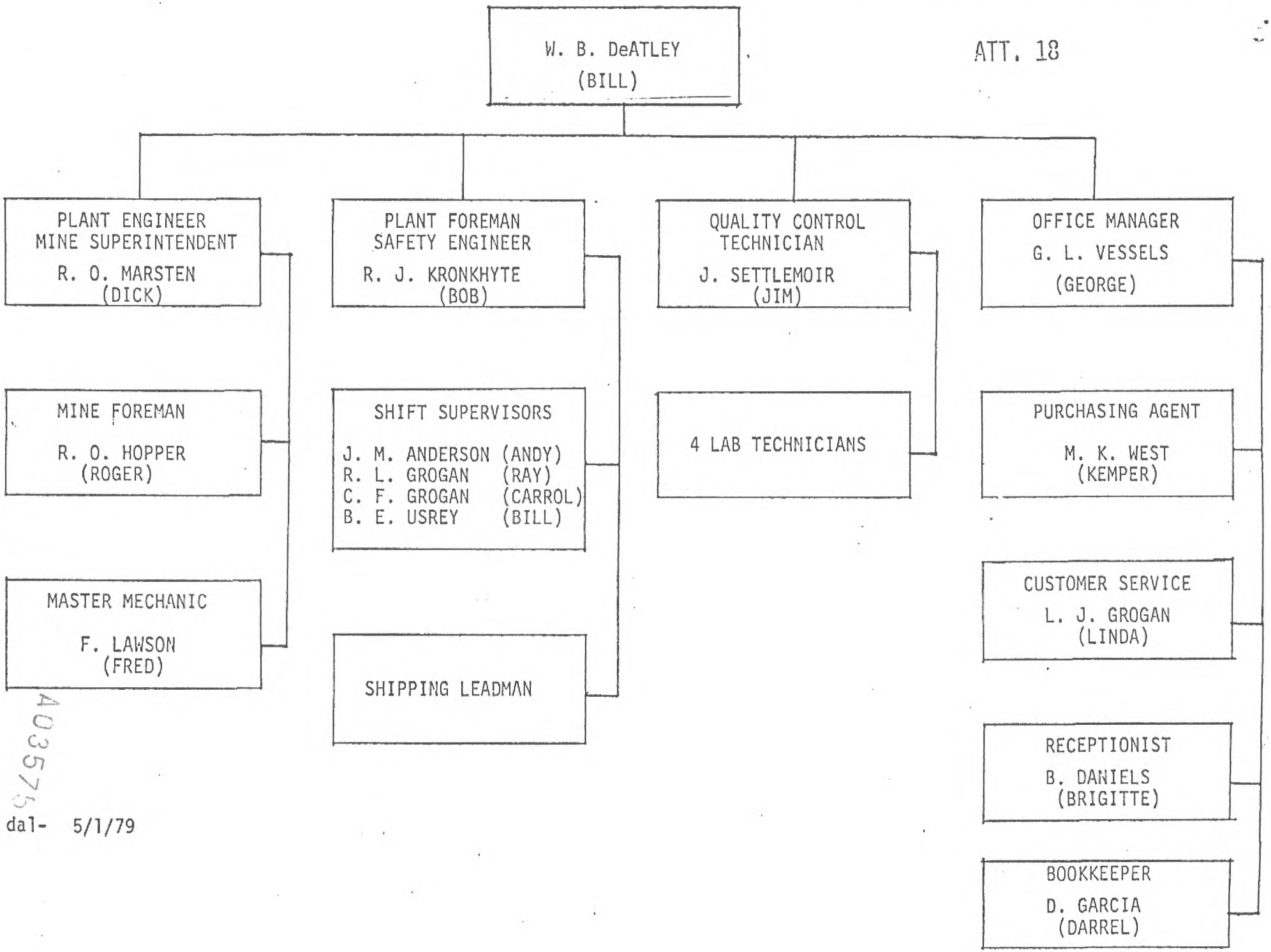
"CALIDRIA" ASBESTOS MARKETING ORGANIZATION
4/1/79



A03574

Union Carbide Corporation Metals Division
"Calidria" Asbestos Operations (5/15/78)

ATT. 18



UCC 008896

A03575

dal- 5/1/79

MAJOR WORLD SOURCES OF ASBESTOS

(Based on 1977 USBM Estimates)

COUNTRY	SHORT TONS
USSR	2,710,000
Canada	1,700,000
So. Africa	419,000
So. Rhodesia	220,000
P.R. of China	220,000
Italy	170,000
Brazil	105,000
U.S.A.	102,000
Australia	61,000
TOTAL	5,879,000

ASBESTOS STATISTICS, M SHORT TONS

(JLM, 3/27/79)

	1978 ESTIMATES	1973-1978 AVERAGE
U.S. CONSUMPTION	640*	728
U.S. IMPORTS	588*	658
U.S. EXPORTS	35*	47
U.S. PRODUCTION	100*	113
UCC PRODUCTION	36	29
UCC DOM. SHMPTS.	26	22
UCC EXPORT	9	7

*FROM USBM REPORTS AND PRIVATE COMMUNICATION WITH R. A. CLIFTON OF USBM

U.S. Chrysotile Consumption - 1978

	Tons	% of Total**
Asbestos-cement pipe	153,000	24.0
Flooring Products*	147,000	23.0
Friction Products	86,400	13.5
Roofing Products*	61,000	9.5
Asbestos-cement sheet	41,400	6.5
Coatings & compounds*	35,200	5.5
Packings & gaskets	25,600	4.0
Paper	22,400	3.5
Insulation (Thermal & Electric)	19,200	3.0
Textiles	9,600	1.5
Plastics*	6,400	1.0
Other*	32,000	5.0
TOTAL	640,000	100

** - "Asbestos", December 1978, pp. 16-18
* - Markets in which UCC partcipates

REB
4/30/79

"CALIDRIA" ASBESTOS PRODUCT APPLICATIONS

PRODUCT	APPLICATIONS
SG-100	Vinyl-asbestos floor tile
SG-130	Masonry coatings
SG-200	Rubber floor tile
Super Visbestos	Drilling muds
SG-210	Mastics Asphaltic coatings Phenolic molding compounds
HPP	Rubber sheet goods Mineral board (Japan) Paper (Japan)
HPO	Asphaltic coatings, Adhesives
RG-110	Asphaltic spray coatings Aluminized coatings Mastics, caulks & sealants
RG-144	Adhesives (Epoxy, casim, phenolics) Coatings Vinyl plastisols (High build, dip coatings) Mastics, caulks & sealants (Vinyl, butyl, polysulfide, bituminous)
RG-244	Polyester resins (Laminating, gel coats, putties) Caulks & sealants (Vinyl, butyl, acrylic, polyurethane) Coatings (Epoxy, urethane, asphaltic)

A03579

1978

CALIDRIA ASBESTOS DOMESTIC APPLICATIONS AREAS

			T	$M	% of Total T	% of Total $
(1)	Floor Tile	SG-100 SG-200	17,500	1800	67	39
(1)	Phenolic Compounds	SG-210 HPO	350	80	1	2
(1)	Roofing Compounds	SG-210 HPO	510	100	2	2
(1)	Asphaltic Coatings	SG-130 SG-144 RG-110	940	180	4	4
(1)	Rubber-Sheet Goods	HPP RG-100	370	130	1	3
(2)	Adhesives	RG-144 RG-244	280	230	1	5
(2)	Sealants	RG-144 RG-244	430	540	2	12
(2)	Polyester Laminates	RG-244	100	200	0.5	4
(2)	Coatings	CG-135 RG-144 RG-244	550	630	2	14
(1)	Drilling Muds	Visb. CSV SHUR	3,000	400	11	9
(1)	Miscellaneous		1,920	280	7	6
			25,950	4570		

(1) Asbestos Industry (2) Non-Asbestos Industry

Summary:

Asbestos Industry	24,590	2970	95	65
Non-Asbestos Industry	1,360	1600	5	35

"Calidria" Participation in Typical Domestic Asbestos Markets in 1978

	Domestic Market, Tons	Potential Segments, Tons	"Calidria" Share of Segment Tons	%
Flooring Products	147,000	75,000	17,500	23.3
Roofing	61,000	6,000	500	8.3
Coatings & compounds (Asphaltic Coatings)	35,200	12,000	1,000	8.3
Plastics (Phenolic & Rubber)	6,400	6,000	700	11.7
Drilling Muds	8,000	8,000	3,000	37.5
Other	24,000	24,000 (?)	2,300	9.6
TOTAL	281,600	131,000	25,000	19.1

REB
4/30/79

A03581

DOMESTIC

MARKET DETAIL

Typical Asbestos Markets for "Calidria"

I. Flooring Products

Total market 147,200 tons

"Calidria" share 17,500 tons (11.9% of total)

Total market includes both tile & sheet goods.

"Calidria" participation only in tile market which is about 1/2 of total. "Calidria" share of this reduced market is, therefore, about 24%.

Major competitors - Carey Canadian - Canada

Atlas Mineral - California

Floor tile market is split as follows:

Carey	50%
Atlas	20%
"Calidria"	24%
Others	6%

II. Roofing Compounds

Total market 61,000 tons

"Calidria" share 510 tons (0.8% of total)

Market includes primarily asphalt compounds using asbestos as a flow control agent. Much of the market requires slightly longer fibers than "Calidria" has available. Realistically we can probably only compete for perhaps 10% of the total or 6100 tons.

A03582

Major competitors - Johns-Manville - Most Canadian suppliers

Carey - " " "

Bell - " " "

Market is split as follows:

J-M	60%
Carey	20%
Bell	19%
"Calidria"	1%

III. Coatings & Compounds

Total market 35,200 tons

"Calidria" share 940 tons (2.7% of total)

"Calidria" particpates primarily in the asphaltic coatings portion of this market which excludes roof coatings. Products include automotive undercoats, coatings for waterproofing below grade concrete and for driveways and tennis courts. The portion of the market in which "Calidria" might compete is unknown, but is probably at least 1/3 of the total market.

Major competitors - Canadian producers

Market is split by all manufacturers (primarily Canadian) and represents an outlet for as much short fiber product as can be allocated to this high volume, low cost application.

IV. Plastics

Total market 6,400 tons

"Calidria" shares 720 tons (11.3% of total)

Market includes primarily plastics used for structures, molded goods, etc. Larger segments include chemical resistant fibers, molded phenolic parts and some rubber goods.

"Calidria" participates primarily in the latter two areas.

Major competitors - Johns-Manville

Market is split as follows:

J-M	89%
"Calidria"	11%

V. Other

(Oil and gas well drilling)

Total market for short fiber asbestos 20,000 tons

"Calidria" share 4,000 tons (20% of total)

Current market is about 6-8000 tons because of regulatory restraints.

Total market could be realized in the absence of regs.

Major competitors - Johns-Manville (Flosal)

Current market is shared by "Calidria" and Johns-Manville about equally.

Production capacity is adequate for full development of market.

AU3584

DOMESTIC

"Calidria" Markets - Not Typical Asbestos

(Viscosity Control)

	Tons	Total Market*	UCC %
Adhesives	280	2500	11.2
Sealants	430	1500	28.7
Polyester Laminates	100	3400	2.9
Coatings	550	4600	12.0
TOTAL	1360	12,000	11.3

*Total Market estimates -

- Modern Plastics, January 1979
- C & P sources (Skeist Laboratory Market Analyses - 1978)
- Assumed nominal loadings for "Calidria," i.e., 1% in polyesters, etc.

REB
4/30/79

AU3585

Markets for "Calidria" - Not Typical Asbestos

I. Adhesives

Total market 3MM tons - portion requiring viscosity additives 125,000 tons - assuming 2% addition level - market "available" 2500 tons

"Calidria" share - 280 tons (11.2% of total)

Major competitors - National Lead (Bentones)
Cabot Corporation (Cab-O-Sil)
Other (Thixcin, etc.)

Market share:

Cabot	45%
National Lead	39%
"Calidria"	11%
Others	5%

II. Sealants

Total market about 150,000 tons split as follows:

Construction	90,000 tons
Automotive	30,000 "
Glass (Insulating)	6,000 "
Aircraft	1,000 "
Highways & Airfields	15,000 "
Appliances	7,000 "

Assuming a 1% loading of viscosity additive, a market of 1500 tons is available.

"Calidria" share 430 tons (28.7% of total)

Major competitors - Cabot (Cab-O-Sil)

National Lead (Bentones)

Market share is split as follows:

Cabot	45%
National Lead	26%
"Calidria"	29%

III. Polyester Laminates

Total market for thixotropic laminates 340,000 TPY

Assuming 1% average addition, 3,400 TPY available

"Calidria" share 100 tons (2.9% of total)

Major competitors - Cabot Corp. (Cab-O-Sil)

DeGussa (Aerosil)

Others (Thixcin, Ircogel, etc.)

Market share is split as follows:

Cabot Corp.	70%
DeGussa	24%
Others	3%
"Calidria"	3%

IV. Coatings

Total market for thixotropic, viscosity modifying and pigment suspending agents is 4600 TPY (1% of 460,000 TPY)

"Calidria" share is 550 TPY (12% of total)

Major competitors - Cabot Corp. (Cab-O-Sil)

DeGussa (Aerosil)

National Lead (Bentones)

Baker Castor Oil (Thixcin, Thixatrol)

Others

Market is split as follows:

Cabot	30%
DeGussa	20%
National Lead	20%
Baker Castor Oil	13%
"Calidria"	12%
Others	5%

REB:dal
4/30/79

A003588

COMPETITORS AND MARKET SHARE

SHORT FIBER ASBESTOS MARKET

	U.S.A.	JAPAN	TOTAL
UCC	19%	16%	18%
J-M	23	11	20
CAREY	47	73	53
ATLAS	11	0	9

VISCOSITY CONTROL MARKET

	U.S.A.	JAPAN	EUROPE	TOTAL
UCC (RG-144 & -244)	11	25	19	15
DEGUSSA	25	70	70	40
CABOT	49	2	5	40
NATIONAL LEAD	10	2	3	3
BAKER	5	1	3	2

AU3589

UNION CARBIDE CORPORATION · METALS DIVISION · P. O. BOX 579 · NIAGARA FALLS, N.Y. 14302 · TEL: 716-278-3376

August 1, 1980

Charles C. Ivie, Esq.
Gibson, Dunn & Crutcher
515 S. Flower Street
Los Angeles, CA 90071

Dear Mr. Ivie:

At Mr. Sibley's request enclosed is a reprint of the article about "Calidria" Asbestos Pellets which appeared in the 10/71 issue of "ASBESTOS".

I have also enclosed other articles which we have published in various journals and which may be of value to you. I have also copied pages from a couple of books on asbestos to indicate that "outside" sources also confirm that longer fibers are used for heat insulation. I'm sure that any publication on asbestos applications would confirm this.

Very truly yours,

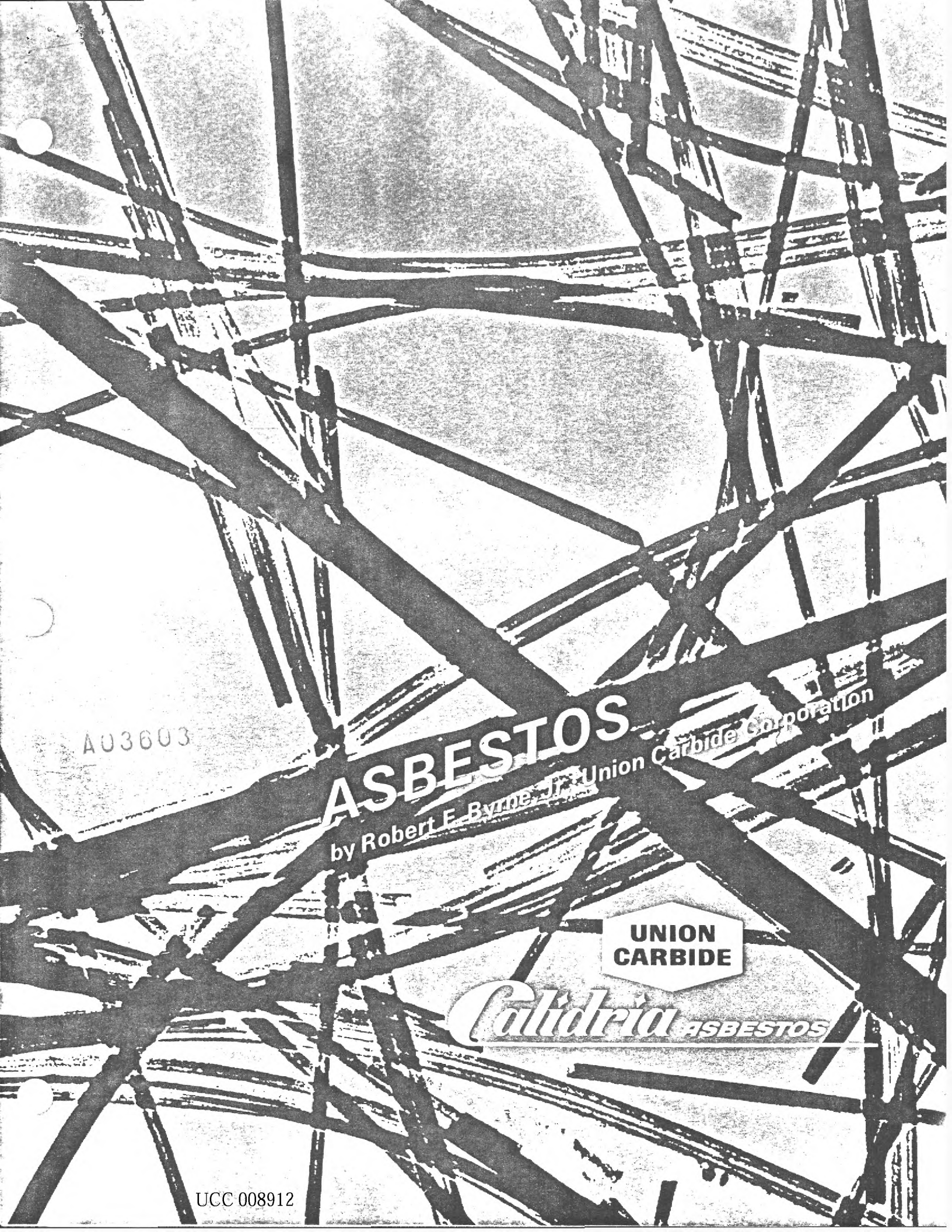
John L. Myers

John L. Myers
Marketing Manager

JLM:dal
Enclosures

CC: J. J. Sibley

A0359C


AU3603
ASBESTOS
by Robert E. Byrne, Jr., Union Carbide Corporation
UNION CARBIDE
Calidria ASBESTOS
UCC 008912

Asbestos

By Robert E. Byrne, Jr.*

Asbestos is a commercial term used for six naturally occurring "asbestiform" minerals that are fibrous, hydrated metal silicates. They include the fibrous form of serpentine, known as chrysotile, and five minerals of the amphibole group: anthophyllite, crocidolite, actinolite, tremolite and amosite.

Chrysotile is the most plentiful and useful form of asbestos. Of the more than 2 billion lb. of asbestos used each year by the plastics industry, about 93% is chrysotile. Its positive surface charge, softness and flexibility, and its low refractive index set it apart from other asbestos. Chrysotile's fiber diameters, less than 0.03 micron, are the smallest among commonly known fibers, and the material has exceptional mechanical strength.

Commercial products based on chrysotile have been introduced which, by chemical modifications of the normal chrysotile fiber, have novel surface properties. These materials are used mainly for viscosity control in antisag and thixotropic applications.

Compared to chrysotile, amphibole fibers are larger in cross-section, harsh, and hard. The amphibole asbestos minerals are anionic in surface charge, and are more resistant to acids than is chrysotile.

Anthophyllite fibers usually occur as fibrous masses containing randomly oriented cubic blocks of fiber up to an inch in length. They are generally used in insulating materials, as filtering media, and as fillers in plastics, paints, and asbestos-cement products.

Crocidolite, or blue asbestos, is found principally in South Africa. Needle-like in structure and possessed of exceptionally high mechanical strength, it is used in plastics, where its pronounced color is not detrimental.

Tremolite and *actinolite* are very similar, except for the higher iron content of the latter. Both are in relatively short supply, and are used mainly as filter media or fillers. *Amosite* is a long yellowish-brown fiber that is harsh and brittle, and is used mainly in thermal insulation.

Low cost, exceptional mechanical strength, and heat resistance account for much of the increasing usage of asbestos in plastic products. It has recently been recognized that the unit chrysotile fibril is a naturally occurring reinforcing whisker. Because of its high strength, stiffness, and aspect ratio, it provides excellent whisker reinforcement. Maximum utilization of these reinforcing potentials, however, requires a high degree of fibril liberation and the absence of extraneous gangue material. Some caution is necessary in selecting a product providing the optimum in these characteristics.

Asbestos is usually graded on the basis of fiber lengths separated by dry screening. While the different grades cannot be precisely characterized by a specific length, grades 2 and 3 are the

*Area Manager, "Calidria" Asbestos, Marketing and Technology, Mining and Metals Div., Union Carbide Corp., P.O. Box 579, Niagara Falls, N.Y. 14302

Table I. Comparative properties of asbestos minerals

Properties	Chrysotile	Anthophyllite	Crocidolite	Actinolite	Tremolite	Amosite
Composition	$Mg_3Si_2O_5(OH)_4$	$Mg_7Si_8O_{22}(OH)_2$	$Na_2Fe_3Fe_2Si_8O_{22}(OH)_2$	$Ca_2Fe_5Si_8O_{22}(OH)_2$	$Mg_5Ca_2Si_8O_{22}(OH)_2$	$(Fe,Mg)_7Si_8O_{22}(OH)_2$
Crystal habit	Fine, easily separable fibers	Prismatic crystals and fibers	Long brittle fibers	Prismatic crystals and fibers	Prismatic crystals and fibers	Prismatic crystals and fibers
Color	White, gray, greenish	Gray-white	Blue	Green	White, gray-white, greenish	Ash gray or brown
Texture	Soft to harsh, also silky	Harsh	Soft to harsh	Harsh	Harsh	Harsh
Flexibility	Very good	Poor	Good	Poor	Poor	Good
Hardness, Mohs	2.5–4	5.5–6	4	6	5.5	5.5–6
Fiber dia., Å	180–300	600–900	600–900	600–900	600–900	600–900
Tensile strength, p.s.i.	300,000–800,000	<4,000	400,000–600,000	<1,000	1,000–8,000	100,000–200,000
Modulus of elasticity, p.s.i.	23.2×10^6	—	27.1×10^6	—	—	23.6×10^6
Fusion pt., ° F.	2770	2675	2180	2540	2400	2550
Specific heat, Btu/lb./° F.	0.266	0.210	0.201	0.217	0.212	0.193
Surface area BET, $m^2/g.$	10–60	7	10	—	—	9
Specific gravity	2.4–2.6	2.8–3.1	3.2–3.3	3.0–3.2	2.9–3.2	3.1–3.3
Refractive index (mean)	1.51–1.55	1.61	1.7	1.63	1.61	1.64
pH	9.5–10.3	9.4	9.1	9.5	9.5	9.1
Electric charge in aqueous slurry	Positive	Negative	Negative	Negative	Negative	Negative
Resistance to acids	Poor	Very good	Good	Fair	Good	Good
Resistance to alkalis	Good	Good	Good	Good	Good	Fair

Table II. Typical changes in resin properties with asbestos reinforcement*

Material	% change				
	Flexural modulus	Flexural strength	Tensile strength	Impact notched Izod	HDT, °F.
ABS	+130	−20	−5	−60	+16
Nylon 6	+170	+100	+85	+20	+200
Phenolic	+120	+50	—	+5	—
Polyethylene	+320	+30	+20	0	+72
Polyphenylene sulfide	+60	+100	+10	+100	+35
Polypropylene	+360	—	−4	+125	+25
Polystyrene	+110	+50	+20	−40	+18

*Optimum reinforcement usually requires 20-40% short fiber asbestos.

longest fibers and grade 7 is the shortest. In general, the longer fibers are more expensive.

One of the few important nonmetallic minerals imported into the U.S. from foreign sources is asbestos. About 10% of our annual usage is produced from domestic sources with a value of over $10 million. The remainder comes mainly from Canada.

Asbestos selection

Asbestos short fiber is normally used for reinforcement, heat resistance, and flow control of plastics, while the longer grades are used for reinforcement and heat resistance in the form of fibers, yarns, or textiles. Chrysotile, as noted previously, is normally chosen for most applications because of its plentiful supply and product uniformity unless the special advantages of another mineral are required. For example, anthophyllite has been employed for reinforcing polypropylene because it allows easier heat stabilization. Recent reports, however, show that this disadvantage of chrysotile can be overcome. One of the amphiboles may be selected also where the poor resistance of chrysotile to acids presents a problem.

The use of short fiber asbestos in plastics products requires adequate dispersion to achieve optimum results. Melt processing is most satisfactorily accomplished in high-intensity mixers such as the Banbury. Dispersion in liquid resin systems also requires high shear devices and maximum viscosity to allow the resin/asbestos mix to absorb maximum energy. The masterbatch technique should be employed wherever practical.

Asbestos use

The largest uses for asbestos in plastics are vinyl/asbestos floor tile and in phenolic compounds. It is also used in myriad other areas including polypropylene, polyesters, nylons, melamines, epoxies, silicones, and vinyls. It is used in product types, including friction materials, heat resistant and electrical components, sealants, and mastics. The applications for asbestos are a balance of some combination of these effects. For example, short fiber chrysotile is used in vinyl asbestos floor tile to improve heat strength and dimensional stability, but requires that particular attention be given to heat stabilization of the resultant product mix during processing.

Since 1965, the consumption of asbestos-reinforced polypropylene by the automotive industry has increased rapidly. This trend toward the use of short fiber products for reinforcement is dependent on the inherent strength and fibril geometry of asbestos.

The volume of short fiber chrysotile used in mastics, sealants, and adhesives of various types is increasing. From 5 to 60% asbestos is used in adhesives to reduce crazing, shrinkage, and embrittlement. Asbestos also reduces cost, increases bulk, and provides controlled penetration and resistance to heat in such adhesives as phenolics, urea, resorcinol, epoxy, nitrile and reclaimed rubber, and silicones. In mastics and sealants, asbestos provides toughness, flow, and penetration control, as well as reduced cost. The colloidal grades of chrysotile are reported to contribute additional performance and handling improvements.

Polyester premixes used to fabricate automotive parts, tractor and marine engine housing, and materials-handling bins and containers often contain short fiber chrysotile to provide flow control, improve surface appearances, reduce shrinkage, and lower cost. The new low-profile systems utilize asbestos for controlled shrinkage, improved mechanical strength, and heat resistance.

The amount of asbestos needed varies with the particular resin system and the fiber length, and degree of openness of the asbestos. Each system has an optimum level for maximum mechanical strength. For example, in phenolics about 25% is typical for asbestos floats, or as low as 5% colloidal chrysotile. Asbestos content may vary up to 60%, however, depending on the levels of chemical, thermal and impact resistance, and the electrical properties desired. Asbestos-filled phenolic and urea formaldehyde resins find use in many electrical applications where heat resistance is required. Asbestos-filled polyester and diallyl phthalate compounds are also used in electrical applications. The asbestos-containing compounds enable molding with exceptional accuracy, molding-in metal inserts easily, and mass producing intricate shapes difficult to fabricate from other dielectric materials.

Phenolic/asbestos laminates used for rocket flame tubes are one example of the increased demand for asbestos-reinforced systems brought about by space age requirements for heat, chemical, and shock resistance.

Calidria

ASBESTOS products for plastics

* Economical
* High Purity
* High Brightness
* Low Moisture
* Less Dust

CALIDRIA Asbestos RG-244

a chemically modified, high-purity fiber with a mineral coating

- for maxmum thickening efficiency and thixotropy in polyester spray-up and hand lay-up laminating resins and gel coats.
- effective thickener for plastisol and organosol adhesives, coatings, mastics, and sealants as well as epoxy and phenolic adhesives.

Advantages:

- Permits high viscosity at low loadings, reducing costs.
- Wets out quickly and disperses easily.
- Improves shelf life, reduces settling.
- Does not add color or opacity at normal loadings.
- Reduces dusting from material-handling operations.

CALIDRIA Asbestos RG-144

a high-purity asbestos fiber without coating

- efficient, low-cost thickener and thixotrope for epoxy, vinyl, and phenolic resins; butyl, polysulfide, and other sealants; and casein adhesives.
- excellent reinforcer for rigid vinyl, nylon, polysulfone, and similar compounds.

Advantages:

- Thickens both epoxy resins and amine hardeners at 1/6 the cost of pyrogenic silica.
- Wets out quickly and disperses easily.
- Has no shear sensitivity.
- Improves shelf life, reduces settling.
- Reduces dusting from material-handling operations.
- Eliminates need for viscosity build-up or thixotropic stabilization additives (except for low viscosity, cycloaliphatic epoxides).

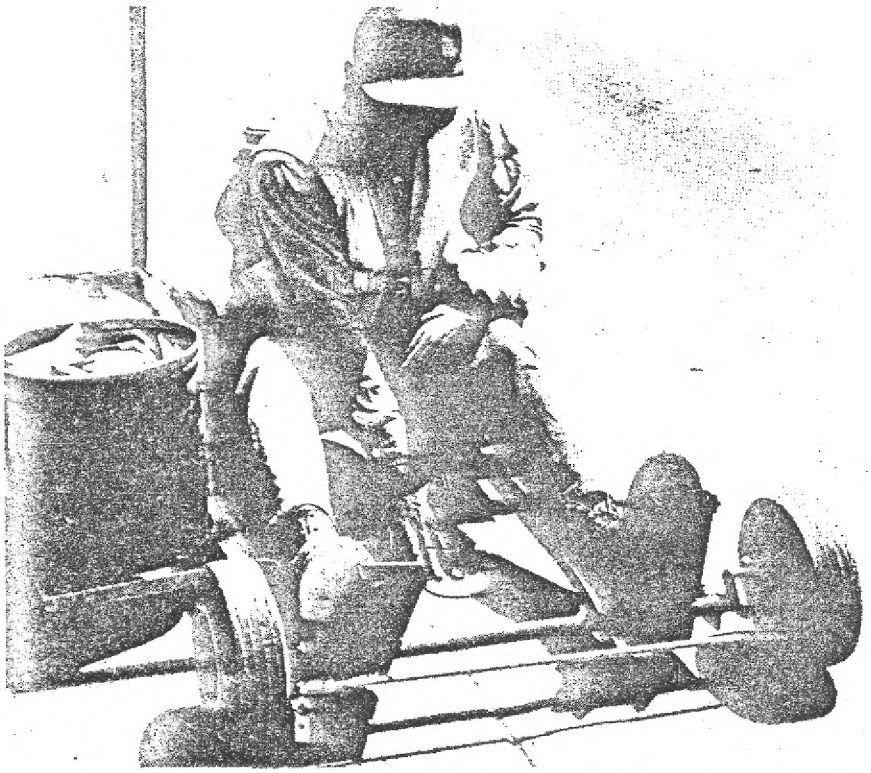
For further information on this "new approach" to thickening and thixotropy, contact your nearest Union Carbide sales office, listed on the back cover.

UNION CARBIDE

THE DISCOVERY COMPANY

A03607

Asbestos beefs up plastics and adhesives to extend their use



Highway markers are bonded with inexpensive, asbestos-modified adhesives. Two components are mixed and dispensed from cart before applying reflectant.

The first single-crystal whiskers to be used by man were asbestos. Since the whiskers' high strength was first measured in a laboratory, scientists have been trying to find ways to harness the potential of asbestos in structural materials.

The tensile strength of single crystals of asbestos has been measured at more than 800,000 psi—as strong as the strongest glass filaments. But so far, strengths achieved in composites do not go beyond those achieved with glass-mat reinforcements.

The thorn to date. One of the chief drawbacks of asbestos has been the inability of researchers to incorporate homogeneously more than 10% to 20% asbestos with structural resins. With only 4% or 5%, resin mixtures become unmanageably viscous.

But this very deficiency is being turned to advantage by Union Carbide chemists, who have developed a number of thixotropic uses for their new resin-grade of chrysotile asbestos. The Union Carbide material, because of its high purity and fine particle size, is easier to incorporate in resinous compounds. Union Carbide's filler is cheaper than other thixotropic agents.

Opening new fields. Union Carbide mines an area in California. Asbestos was discovered there just a few years ago, and it is believed to be the largest source of high-purity asbestos ore in the world. The extra-high purity of this grade has opened up a whole new range of uses for asbestos.

An important difference in the California grade of asbestos is its random orientation, which permits the wet-processing system. Wet-processing breaks up individual fibers into easy-to-handle dust-free pellets. The separation of fibers yields a more efficient reinforcing effect in resin-based products.

Another application for asbestos is as a reinforcement for thermoplastics. Adding 20% asbestos to Nylon 6 doubles both the flexural and tensile strength of the unreinforced material. The increase matches the strength improvement obtained with chopped-glass fibers.

Saving money. Most other applications for the new grade of asbestos have been in viscosity-control uses such as with epoxy and polyester compounds. Of course, some reinforcing effect also results.

For example, traffic-marker adhesives based on epoxy resins have been made 60¢ to 70¢/lb. cheaper by using the asbestos thickener.

About 30 gm of adhesive are used by the State of California's Highway Dept. in putting down round-button pavement markers. About 3 million of these markers will be applied by the end of this year: The use of asbestos has added up to some important savings for the California tax payer. (2.127)

from PRODUCT ENGINEERING/October 21, 1968

Reprinted from

PAINT and VARNISH PRODUCTION

FEBRUARY 1971

Resin-Grade Asbestos Boosts Thixotropic Qualities of Epoxies

Based on the results of a year-long series of laboratory and in-the-field tests, Sta-Crete, Inc., San Francisco, Calif., is now using a resin-grade asbestos instead of pyrogenic silica as the standard thixotrope in most of its epoxy coatings.

Jane A. Black, president of Sta-Crete, reports that the company has found that the asbestos, manufactured by Union Carbide Corp., New York, N.Y., offers many important processing advantages. "It is simpler to handle," she said, "and dispersion is easier, using either high or low speed mixing equipment. In addition, a dusting problem that prevailed with silica was eliminated. We are no longer concerned with particles floating in the immediate area when the thixotrope is dumped into the mixing tank.

"Another benefit gained," Miss Black continued, "is improved economy. The asbestos costs about 75 per cent less than the silica."

In actual use, coatings with the asbestos additive reportedly have better consistency and improved thixotropic properties. As a result, the coatings can have lower viscosity but still offer good sag resistance for vertical surface applications.

The effectiveness of Sta-Crete's coatings in this type of application was shown in the use of a new epoxy coating as an exterior facing on a new high school building in Summerville, S.C. The coating was specifically formulated around a particular form of resin-grade asbestos, Union Carbide's Calidria Asbestos, Resin-Grade 144.

The contractor, Ed Scarpa, of Charleston Tile & Marble Co., Charleston, S.C., pointed out that the coating was not gritty or sandy and did not contain any lumps or other undesirable aggregates that could hinder mixing or application of the two-part material. Installation involved troweling the coating onto the masonry surface. Because of its high thixotropy, the facing had sufficient flow to permit easy, uniform application with no run-off.

Sta-Crete found that the coating offered a number of other advantages. The material is applied in place rather than being installed as a prefabricated panel. As a result, the contractor did not have to be concerned with joint alignment or masonry plumb errors, two conditions that would have required costly, time-consuming corrections or adjustments. Use of the coating, Mr. Scarpa estimated, lowered material and installation costs for the 12,000-square-foot epoxy facing to about 50 per cent less than what would have been incurred with other facings.

A workman trowels the epoxy coating onto the masonry surface of the new Summerville High School in Summerville, S.C. Because of its high thixotropic qualities, the material had sufficient flow to permit easy, uniform application.

Resin-Grade Asbestos Improves Thixotropic Properties of Highway Marker Adhesive

Reprinted from ADHESIVES AGE, March 1969

By specifying resin-grade asbestos as the viscosity control agent for epoxy-based adhesives used to affix button lane markers on California highways, the state's Division of Highways eliminated an adhesive storage stability problem that had prevailed with previous thixotropes.

In California, pavement markers are installed on most state highways in accordance with a state law enacted a number of years ago. Designed to replace striping, the raised markers are used to delineate traffic lanes, especially at night and during wet weather. Since every ninth marker is reflectorized, lane differentiation is accomplished primarily by visual means. The raised markers also give an audible sound as a vehicle rides over them.

An average of 30 grams of adhesive is used per button, but the amount varies depending upon marker shape — round or square — and on the type and condition of the pavement. Although about three million button markers were applied in 1968, the program will continue for several more years before all California roads will be equipped as prescribed.

All adhesives used are pre-tested by the highway division's test laboratory, placed in specific inventory, and released to contractors by state inspectors at the time of application. In many instances, storage time is quite extensive, sometimes under temperatures that reach 115° F. or higher. Under these circumstances, the viscosity and thixotropy achieved by the use of colloidal silica in the "A" or epoxy resin component is unstable and loss is excessive and quite rapid. When this instability occurred it resulted in adhesive rejects or in critical runoff during application that left insufficient resin to assure a proper bond.

To improve these characteristics, the state highway division sought a thixotrope that would extend shelf life without any effect on adhesive performance or structural strength.

After testing several different materials, the laboratory found that a resin-grade asbestos, such as Union Carbide Corporation's Calidria Asbestos, Type R-G 144, best met the storage stability requirements stipulated in state specifications covering pavement markers and their adhesives. Under these regulations, the adhesive could not change in viscosity and shear index by more than plus or minus 15 per cent when stored for two weeks in closed containers at 115° F., ± 3° F.

Resin-grade asbestos proved acceptable in all oven-aged stability tests and in all viscosity and thixotropy measurement tests. The results showed little or no drop in viscosity, resulting in a highly stable adhesive that had an excellent shelf life.

Significant processing advantages also are offered. For example, the asbestos is less costly than other thixotropes, with an average reduction of about 60 to 70 cents per pound. Processing costs also are lower because comparatively smaller amounts of asbestos are required. In addition, resin-grade asbestos is easier to store, handle and disperse. Its excellent shear strength eliminated the need for polar additives. Because of these improvements, processors are now assured of producing adhesives with consistent viscosities that do not drop even after prolonged storage under high heat.

On the left a predetermined amount of adhesive is applied to specific locations on road surface with truck-mounted meter-mix and dispense equipment. On the right a button marker is hand applied on the prepared spot. The thixotropic properties of resin-grade asbestos keep adhesive viscosity constant, assuring no runoff during application.

UNION CARBIDE
UNION CARBIDE CORPORATION
CHEMICALS AND PLASTICS
270 PARK AVENUE, NEW YORK, N.Y. 10017

F42502
046-9