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NEW ADDITIVES INDUCE THIXOTROPY, PROVIDE SAG AND VISCOSITY CONTROL

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Portland, Seattle, and
Vancouver, B. C.

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UC-1531

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NEW ADDITIVES INDUCE THIXOTROPY, PROVIDE SAG AND VISCOSITY CONTROL

About twelve years ago a Union Carbide exploration geologist was tramping through central California in search of nickel or other metallic mineral deposits which would be of value to the Corporation. Although neither of us realized it in 1957, what he found is what I'm here to talk about this evening:

CALIDRIA ASBESTOS

The word "asbestos" is a commercial term applied to several fibrous silicate minerals which are fire-proof and capable of being processed into flexible fibers. Although there are six different varieties of asbestos, chrysotile is by far the most common and accounts for some 90% of world production. Canada produces 1½ million tons per year, while in the United States small quantities are mined in Vermont, Arizona and California. California accounts for over 50% of U.S. production.

There are certain characteristics which are unique to chrysotile asbestos, and which make it the most-used variety:

1. A lower index of refraction, 1.51 to 1.55
2. Softest and most flexible fibers
3. Positive or cationic surface charge
4. High tensile strength, up to 800,000 psi

Figure 1 compares the physical properties of the six different types of asbestos, and you will note the major disadvantage of chrysotile is poor resistance to acid. However, in spite of this, it is estimated that chrysotile asbestos is found in over 3000 applications.

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The Source of CALIDRIA Asbestos is a unique deposit located in the southern part of the Diablo Mountain range, in Fresno and San Benito Counties (see Figure 2). It is in what is known as the New Idria mining district, which has long been famous as the oldest producing mercury mine in the United States. All exploration activities were centered in the nearby town of Coalinga, and the deposits became known as Coalinga Asbestos.

The Coalinga deposit is unique for several reasons, not the least being that it is thought to be the largest single mineral deposit in the world. 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. Of course Union Carbide does not control all the claims and is not the only company mining the deposit. But, based on exhaustive drilling programs, we feel that we have the richest deposits and ample ore supply for up to one hundred years of operation. Although mine owners try to keep such information confidential, Canada's ore reserves have been estimated at less than 50 million tons.

Chrysotile asbestos occurs only in serpentine, a fine-grained rock composed almost entirely of hydrous magnesium silicate minerals similar to chrysotile in composition. Figure 3 depicts its crystal structure. 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 Figure 4).

The Coalinga deposit bears little resemblance to other serpentine bodies found throughout the world since most of the mass has been highly sheared and pulverized. 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

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in Yugoslavia. In contrast to the cross-fiber arrangement of conventional ores, the Coalinga deposit occurs as a swirling mesh of disoriented fibers (see Figure 5). Each fiber or fiber bundle is only in point contact with its neighbor. The "fiber assay" of the ore we process ranges from 50-60% and is all classed as short fiber, similar to a Canadian Grade 7.

As mentioned before typical Canadian deposits yield varying fiber lengths, ranging from several inches down to several microns. These are designated by Canadian standards from Grade 3 (spinning fibers) to Grade 7 (shorts and floats). In addition to removing large quantities of rock from asbestos fibers, the fibers must also be classified by length. Conventional Canadian processing methods include blasting, crushing, grinding, and air classifying. Figure 6 shows the result of processing coalinga ore by the very best dry methods. Fiber bundles are still very much in evidence and the full potential of the fiber cannot be utilized.

We mine the asbestos ore by conventional open pit methods. After scraping off 10 to 20 feet of overburden, ripper-equipped bulldozers and self-propelled scrapers are used to remove the ore from the deposit. The ore is loaded into bottom-dump trailers through a 3/4-inch screen and hauled to the mill site. Because of the high production rates obtainable with a minimum amount of equipment, the mine is operated only during the summer season. Inclement weather and poor road conditions preclude efficient operations during other parts of the year. Now let me summarize the unusual characteristics of the Coalinga deposit:

1. All chrysotile
2. All short-fiber
3. Random-oriented fibers
4. Over 50% fiber content
5. About 20% moisture content

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To take advantage of the unique features of the Coalinga deposit, Union Carbide developed a hydraulic beneficiation process to provide the product shown in Figure 7. Conventional mineral processing techniques such as wet screening and grinding, are utilized; but the process is proprietary and I cannot describe it in detail. I can say that it consists primarily of three systems: rock-fiber separation, refining, and special treatment. This provides us with three basic product categories: fiber, colloidal and modified. Lets take a close look at the fiber before we proceed to a discussion of particular grades and their various applications. It is this individual fiber, its purity and liberation, which makes CALIDRIA Asbestos different from any other asbestos product available today.

You will remember from Figure 3, depicting the crystal structure of chrysotile asbestos, that there is a slight curvature in the configuration. This represents the tubular form of the fibers, which consist of about ten concentric layers of brucite (magnesium hydroxide) and silica. The tubes have an external diameter of 260Å and an internal diameter of 110Å. Electron micrographs, recently made in Japan of the ends of the fibers, have proven the tubular theory. The length of the fibers varies greatly, probably from 100 to 1000 times the diameter; but we feel that the average L/D ratio is about 200. This means that the average fiber length is about 5 microns; and, from this, we have estimated that there are 10^{14} fibrils in one gram of CALIDRIA Asbestos. (For mathematic buffs this means that if all the fibers in one gram were placed end to end they would stretch out 300,000 miles).

But let's look at some more practical and measurable numbers and physical characteristics. From strictly geometrical considerations, an assemblage of closely packed hollow tubes with the diameters mentioned previously

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would have a surface area of 105 square meters per gram ($35m^2/g$ internal and $70m^2/g$ external). Based on BET-nitrogen tests, our asbestos products have surface areas of 60 to $80m^2/g$. This compares to 10 to $30m^2/g$ for average Canadian asbestos, and verifies the electron microscope observations that there is little or no foreign material between the fibers. Also, since we use a wet process, the tube interiors are probably cleaned out to some extent.

Some interesting values are shown in Figure 8 and should facilitate a comparison between asbestos and materials with which you are more familiar.

To summarize, CALIDRIA chrysotile asbestos fibers have the following important characteristics:

1. High surface area, $60-80m^2/g$
2. High tensile strength, up to 800,000 psi
3. Cationic surface charge
4. Colloidal form, average L/D of 200
5. Extremely high purity, 90-99% fiber
6. Essentially inert
7. High temperature stability to about 700^oC.
8. Low refractive index, 1.51-1.55

As I mentioned previously Canadian asbestos is classified by fiber length into Grades 3 through 7, described as follows:

Grade 3 - Spinning fibre
4 - Shingle fibre
5 - Paper fibre
6 - Waste
7 - Shorts

Grade 7 is divided into numerous sub-grades, such as: 7D, 7M, 7R, 7T, etc.; which have slightly different characteristics. Figure 9 compares the

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"average" Canadian Grade 7 with CALIDRIA products.

Figure 10 shows all the CALIDRIA products and their major market applications. The discussion which follows, to the best of my ability, will be about products and applications of direct interest to you.

I don't know if the tape joint, or drywall industry is considered to be in the coatings field; if not, it is certainly a related area. Figure 11 shows a typical ready-mix tape joint compound utilizing CALIDRIA S-G 210. The important factor to note is that the S-G 210 content is only one half the usual amount of asbestos used in such a formulation. Mineral content and water demand are maintained constant by increasing the inexpensive limestone addition. Textured coatings utilize two other products: S-G 130, a coarser grind than S-G 210, and T-135, a titanated asbestos product.

To digress just a moment, T-135 is colloidal, or High Purity Asbestos co-flocculated with anatase TiO_2. It was the first of our modified products. Figure 12 is an electron micrograph which shows how the TiO_2 particles are dispersed along the fibers. They are bound together by their opposite electrical charge and cannot be separated by mechanical energy. T-135, in the paper industry, usually replaces TiO_2 on a pound-for-pound basis with no loss in brightness or opacity. This is due to the efficient dispersion of the TiO_2 by the asbestos fibers. T-135 is just being introduced to the texture coating formulators and is showing very good promise as a valuable additive. Good body and high brightness can be achieved with a single product.

The potential for an asbestos/rutile product is obvious and we are working toward that end. Even though CALIDRIA fiber is very small, the particle size is presently too large for widespread application in finish coatings,

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especially interior.

An application where the particle size has been adequately small to really offer some advantages is in asphalt compounds. CALIDRIA Resin Grade 110 was developed for this application, especially in automobile undercoatings, and has proved to be quite valuable. Figure 13 shows the improved thickening efficiency of R-G 110 in a coal tar residue (CP-524). Besides offering good bodying at low concentrations, R-G 110 is essentially non-abrasive and meets the demanding performance of airless spray applications.

Viscosity and thixotropy are two very important words used when talking about liquid resin systems. Viscosity, of course, is a measure of a material's resistance to flow; or, as Webster so aptly puts it: "the state of being viscous". (You can check this when you get home, but he defines VISCOUS as "having viscosity".) Webster, at least in his Collegiate Edition, avoids thixotropy completely; but it is a property which is required in a coating, so we can't ignore it. A thixotropic resin is one which is "thin" when energy is applied, such as pumping or spraying; but "thick" under static conditions. You might think of catsup as thixotropic: thick in the bottle, but when you apply energy to the bottom--look out! A better example might be DuPont's Lucite paint, or approved equal, which spreads easily with just the energy from a brush stroke; although, in the can, it looks like paste. Resin-Grade 144 is a particularly effective thixotrope and viscosity control agent for epoxy resin systems. Figure 14 depicts some of its typical physical characteristics. It disperses readily in liquid resins and hardeners with a Cowles Dissolver or similar high-shear mixer, and over-mixing does not destroy its effect. Epoxy systems containing R-G 144 have excellent aging characteristics; and, up to 2 or 3 phr, are amazingly clear.

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Resin stability is the main reason that R-G 144 has been included as the thixotrope in the California Division of Highways specification for adhesives used in applying lane markers. Formulations for both Standard-Set and Rapid-Set adhesives are shown in Figure 15. At storage temperatures which sometimes reach 115°F., adhesive components containing pyrogenic silica were subject to drastic changes in thixotropy and viscosity. The state found that not only did R-G 144 provide a stable resin, but it also did not detract from adhesion or strength properties. Processing advantages, including reduced cost, are also realized.

Unlike some other thixotropes, R-G 144 is effective with amine hardeners; and no amine salts are required for viscosity build or thixotropic stability. The thickening effect of different thixotropes is shown in Figures 16 & 17.

Figures 18 & 19 depict the thixotropic effect of R-G 144 and two other thixotropes in epoxy and hardener respectively. With epoxy/hardener systems, each loaded with 4% R-G 144, 70 mil thicknesses can be held at room temperature; and up to 40 mil thicknesses can be held, sag-free, at 80°C. Figure 20 shows the results of some of these tests.

The value of R-G 144 as a thixotrope is not limited to epoxy resin systems, as it performs equally well in many other organic systems. It is being used as a thickener for greases, bituminous mastics and sealers, butyl rubber and polysulfide sealants, heat curable vinyl plastisols, casein and phenolic adhesives, etc. In addition to viscosity control and thixotropy, R-G 144 also provides some measure of reinforcement.

The first single-crystal whiskers used by man were asbestos fibers. As mentioned earlier, the tensile strength of asbestos fibrils has been

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measured at more than 800,000 psi, as strong as the strongest filaments. But so far, strengths achieved in composites do not go beyond those achieved with glass-mat reinforcements. We have found good whisker reinforcement with R-G 144 in rigid vinyls (with excellent see-through up to 30 phr loading), nylon molding compounds, polysulfones and others.

The whisker theory says that above some critical volume loading, discontinuous short fibers reinforce a given matrix as well as a continuous one of the same material. This is true because the many short fibers are in such close proximity that the central load bearing portions can transfer an applied load from one to the other without the fiber ends becoming involved. The basic requirement for most resin systems is that the 4D ratio be at least 90. The R-G fiber, at 200:1, is well above the minimum; and Figure 21 depicts the superior reinforcement of VYNS (a PVC-PVA copolymer) with R-G 144 compared to two Canadian asbestos products. These data represent the first work done in this area and show the distinct advantages of a high purity, fully-liberated fiber product which contains 99% asbestos rather than the 60% normally contained in competitive asbestos products.

Only modest improvements are effected in several of the low cost, high volume resins such as styrenes and polyethylenes. However, very impressive results have been achieved in polymers derived from polar monomers, such as phenoxy, polysulfone and nylon. These data are tabulated in Figure 22. Dramatic increases in tensile, flexural, and impact strength are effected with additions of 15-30% R-G 144. In Nylon-6, R-G 144 imparts improvements very similar to chopped glass, at considerably less cost. Similar improvements have also been found in Nylon 6/10 and 6/6.

Although R-G 144, at high loadings, is effective in thickening polyester

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resin systems, it was apparent that this product could not compete with existing thixotropes in such applications. Through the efforts of Dr. Steve Chwastiak of our Niagara Falls R & D staff, another "new" asbestos product was developed.

R-G 244 is a chemically modified fiber developed to provide maximum thickening efficiency and thixotropy in polyester spray-up and hand lay-up laminating resins. Figure 23 compares the thickening efficiency of R-G 244 and pyrogenic silica in a typical polyester resin.

It is also a very effective thickener in vinyl resin sealants and for organosols and plastisols used in a wide variety of adhesives, coatings, mastics and sealants. Figure 24 depicts a suggested heat-curable vinyl sealant formulation in which R-G 244 imparts a high degree of sag control and promotes adhesion. In most systems R-G 244 does not contribute color or opacity. Optimum efficiency, greatest stability, and lowest cost are obtained through the use of sonic dispersers and high energy mixers. However, especially at low viscosity levels, R-G 244 can be incorporated with low shear, propeller-type stirrers. Since R-G 244 imparts little, if any, color, it is being rapidly accepted as a thixotrope for polyester gel coats.

The thixotropic effect which R-G 244 imparts to a polyester resin is depicted in Figure 25. Here you will note that a high shear, where a resin would be sprayed, the viscosity is lower than with pyrogenic silica; and at low shear, where the resin would come to rest on a surface, extremely high viscosity is developed. This prevents sagging and facilitates the maintenance of a smooth uniform coating.

You no doubt have noted during my discussion that in almost every application,

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sag or viscosity control has been an important factor. This physical characteristic is required in almost all liquid systems, aqueous, or resinous; and including coatings, adhesives, sealants, laminates, and molding compounds. And the secret to the success of CALIDRIA Asbestos is related directly to its ultimate purity and fiber liberation. I hope that through this paper I have conveyed the idea that CALIDRIA Asbestos fiber is different and that its range of applications is limited only by your imagination.

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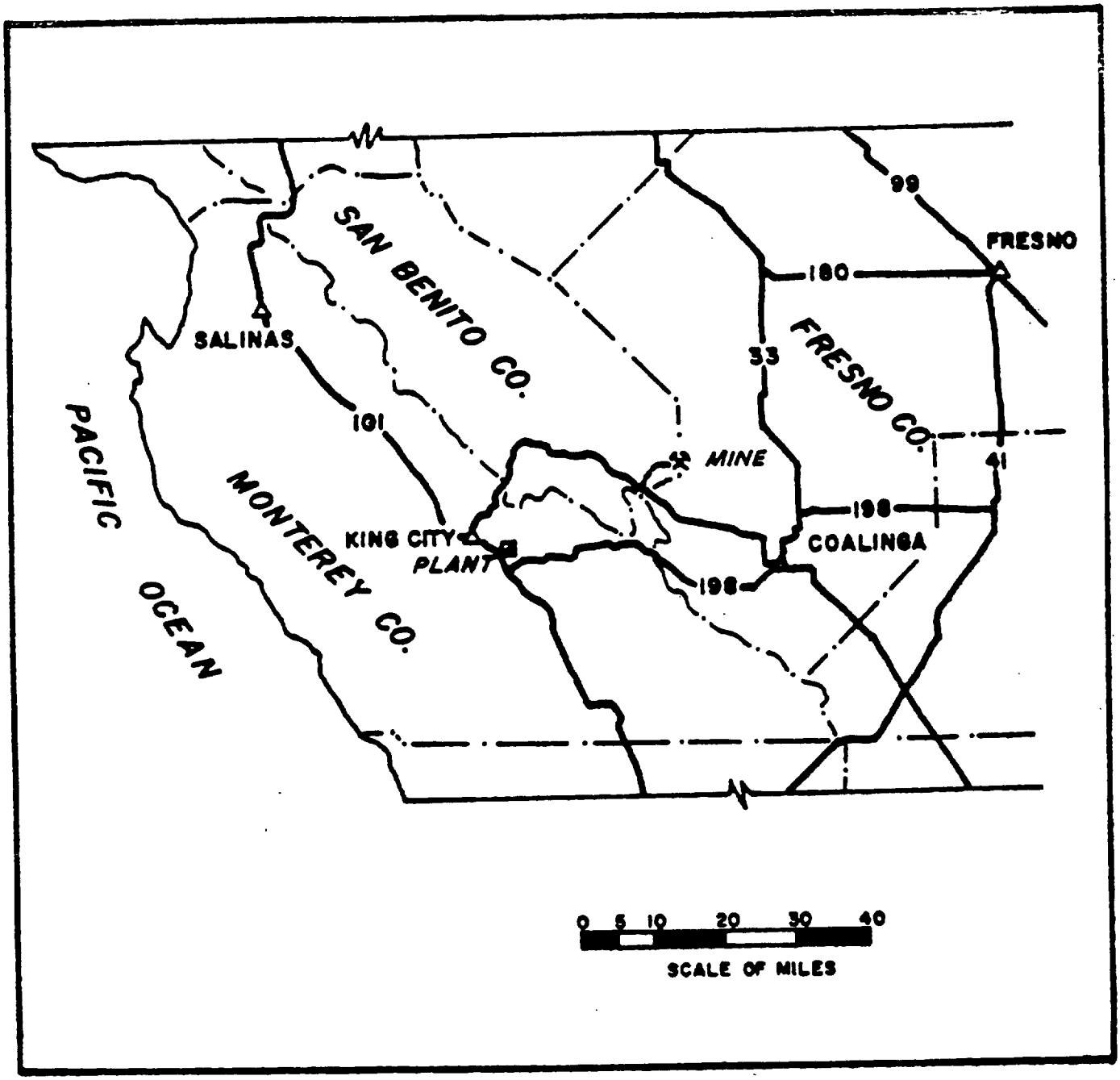
PHYSICAL PROPERTIES OF ASBESTOS MINERALS

PROPERTY	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, thin, 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
Luster	Silky	Vitreous to pearly	Silky to dull	Silky	Silky	Vitreous to pearly
Occurrence	Altered ultrabasics and intruded limestone	Crystalline schists and gneisses	Fe-rich, argillaceous schists	Metamorphosed limestones and crystalline schists	Metamorphosed limestones and Mg-rich rocks	Crystalline schists
Veining	Cross-fiber, Slip-fiber, Massive fiber	Slip-fiber Massive fiber	Cross-fiber	Slip-fiber Massive fiber	Slip-fiber Massive fiber	Cross-fiber
Hardness	2.5-4	5.5-6	4	6	5.5	5.5-6
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
Texture	Soft to harsh also silky	Harsh	Soft to harsh	Harsh	Harsh	Harsh
Tensile Strength (psi)	80,000-100,000	4000	100,000-300,000	1000	1000-8000	16,000-90,000
Electric Charge	Positive	Negative	Negative	Negative	Negative	Negative
Resistance to Acids and Alkalis	Poor-Acid Good-Alkalis	Very good	Good	Fair	Good	Good
Flexibility	Very good	Poor	Good	Poor	Poor	Good
Impurities Usually Encountered	Magnetite, chromite, calcite	Magnetite	Magnetite	Calcite	Calcite	Magnetite

Fig. 1

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Location of Union Carbide's CALIDRIA Asbestos operation

Fig. 2

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FIGURE 3. Crystal structure of chrysotile asbestos.

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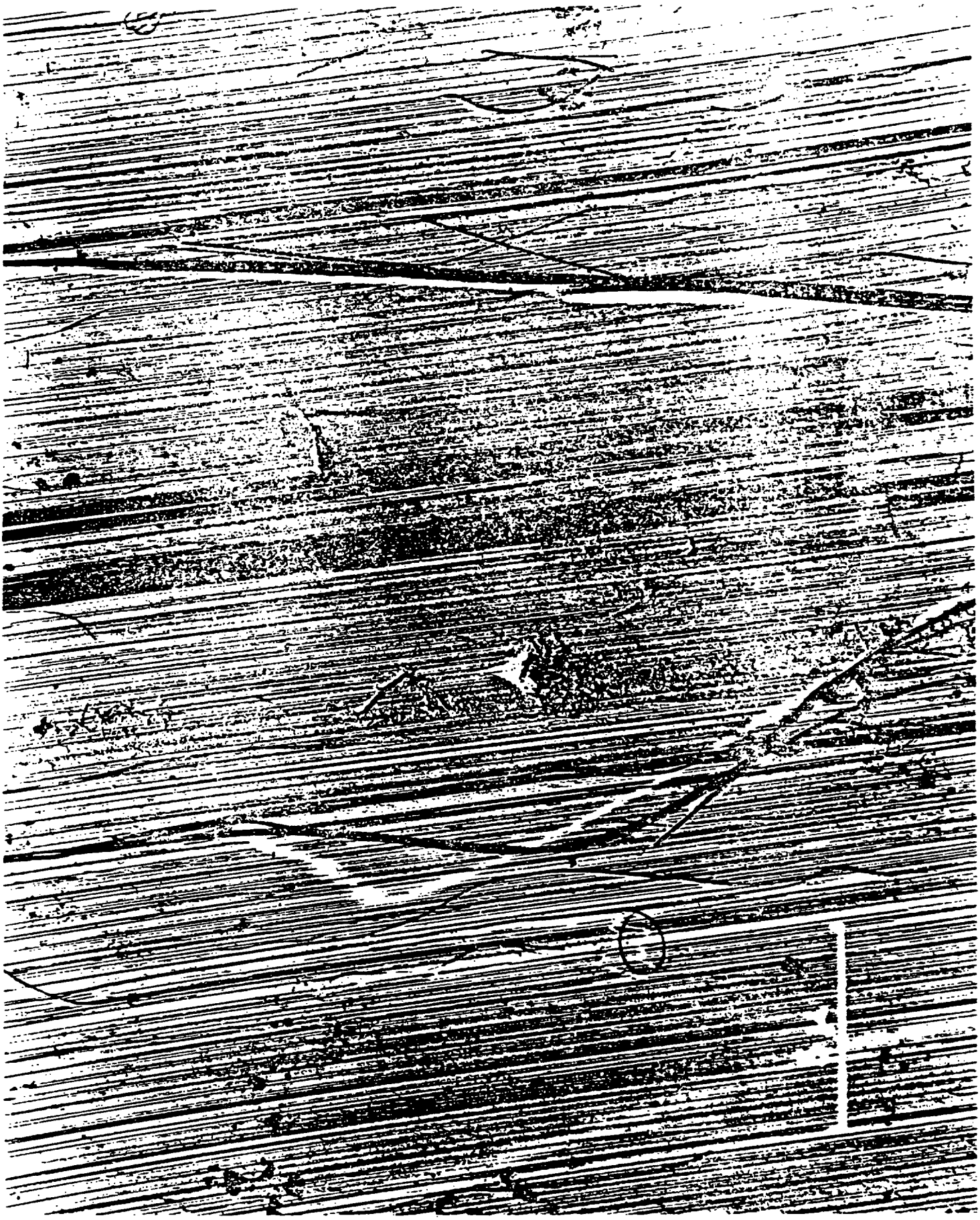


Fig. 4 - Electron Micrograph of typical Canadian asbestos fiber structure

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Fig. 5 - Electron Micrograph of typical Calidria asbestos fibers

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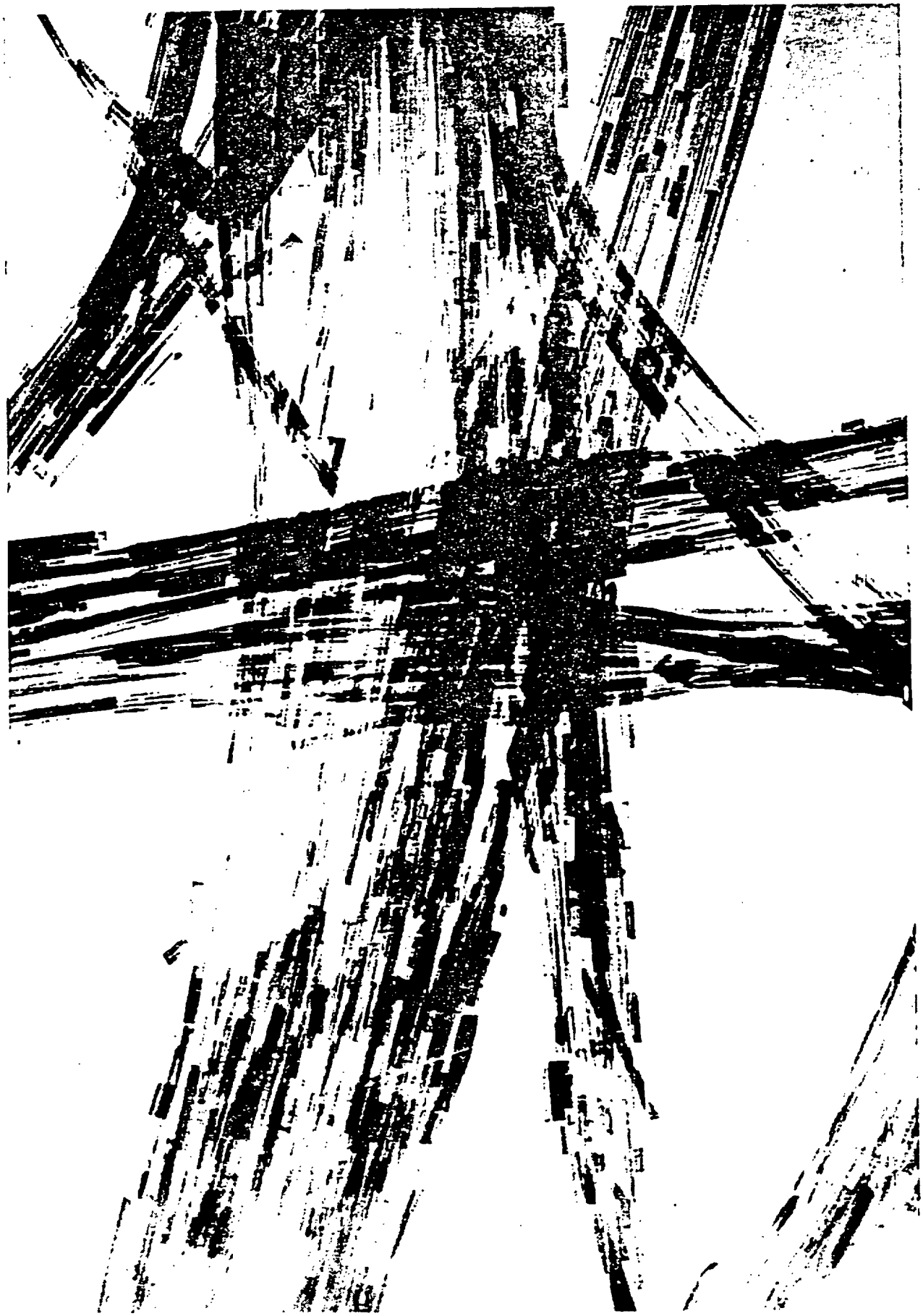


Fig. 6 - Electron Micrograph of dry processed asbestos fibers A09763

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Fig. 7 - Electron Micrograph of wet processed Calidria asbestos fibrils

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COMPARATIVE PHYSICAL PROPERTIES OF WELL-KNOWN FIBERS

Fiber	Diameter, inches	Surface Area m^2/gm	Tensile Strength, psi
Human Hair	0.0016	-	-
Wool	0.0100	1.0	-
Nylon	0.0003	0.3	-
Glass	0.0003	-	100-200,000
Cotton	0.0004	0.7	73-89,000
Piano Wire	-	-	300,000
CALIDRIA ASBESTOS	0.000001	60-80	up to 800,000

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Fig. 8

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PHYSICAL PROPERTIES OF CHRYSOTILE ASBESTOS

PROPERTY	AVERAGE CANADIAN	UCC PRODUCTS STD. GRADE	UCC PRODUCTS HIGH PURITY
SURFACE AREA $M^2/G.$	10-30	50-60	60-80
OIL (DOP) ADSORPTION G./10 G.	4-6	8-10	10-14
WATER RETENTION ML.H_2O/20 G.ASB.	12-20	23-32	33-40
REFLECTANCE %	54-70	62-72	74-77
MAGNETITE %	3-6	<2.0	<0.60

Fig. 9

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CALIDRIA PRODUCT DESIGNATION	APPLICATION
S-G 100	Vinyl asbestos and asphalt floor tile
S-G 144 (Visbestos)	" " " " " "
S-G 130	Texture coatings, acoustic compounds
S-G 210	Tape Joint compounds
SG-200 Cracked (Super-Vis.)	Pulp and Paper Industry
HPP	P & P, waste treatment, pollution control
HPO	P & P
T-135-P	P & P, textured coatings
T-135-O	Asphalt compounds, polyester pre-mix
R-G 110	Thixotropic thickener, resin systems
R-G 144	" " , polyester resins
R-G 244	

CALIDRIA Asbestos Market Applications

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Fig. 10

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TJC READY-MIX

STARTING POINT FORMULATION, 1-GALLON MIXER, 4000 GRAMS DRY WEIGHT

Ingredients and Order of Addition	% by wt. dry basis	grams to weight	dry grams	grams water
1. Water (equivalent to 36.0% by wt.) (c)	--	--	--	1002.0
Note: Start the mixer on slow stirring				
2. CELLOSIZE TJC Grade Union Carbide	0.50 (a)	20.0	20.0	--
Note: Add the particles slowly. Make sure no lumps are added. Mix until the particles are wet.				
3. Bacteriastat, "Dowicide" A (Dow Chemical)	0.20 (a)	8.0	8.0	--
Note: Continue stirring until the thickner is in solution. Usually takes 4-5 minutes.				
4. Pigment Dispersant: "Daxad" 30 (Dewey and Almy), about (25% total solids)	0.60	96.0	24.0	72.0
5. UCAR Latex 131, Union Carbide (59.0-61.0% total solids)	6.60	440.0 (b)	264.0	176.0
6. Filming Aid: Ethylene Glycol Union Carbide	1.00	40.0	40.0	--
Note: Mix until the above mixture is homogeneous (well dispersed)				
Add the fillers below individually or as a mixture				
7. Asbestos, Calidria SG-210 Grade, Union Carbide	4.50	180.0	180.0	--
8. Mica (P-80-F), (Western Mica)	21.00	840.0	840.0	--
9. Clay, ASP-400, (Minerals and Chemicals Phillip)	4.00	160.0	160.0	--
10. Antifoam: NOPCO PD No. 1, (Nopoco Chemical)	0.10	4.0	4.0	--
11. Calcium Carbonate, No. 1 White, (Thompson-Weinman)	61.50	2460.0	2460.0	--

The above mixture is mixed for 120 minutes in a 1-gallon Baker-Perkins Sigma Blade Type mixer at 79 r.p.m.

NOTES:

(a) These can be added as a 2.0 percent by weight pre-mix concentrate. The concentrate is prepared using the addition of bacteriastat as indicated. When this is done, a corresponding correction must be made in the initial water charge.

(b) Based on an average of 60.0% total solids.

(c) Based on the fillers recommended here. The water demand will differ with the type of dry fillers.

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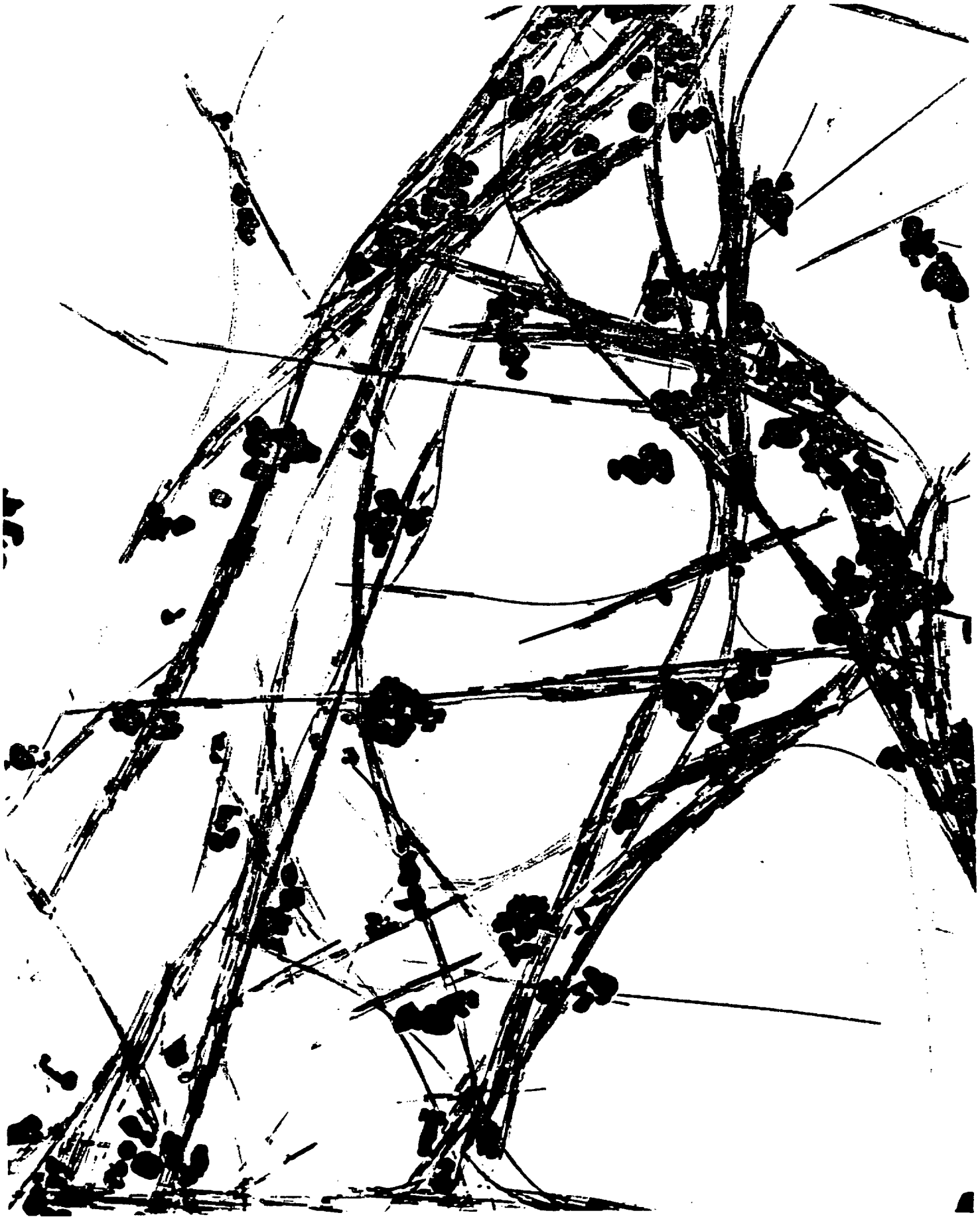


Fig. 12 - Electron Micrograph of Titanated Asbestos, CALIDRIA Type T-135

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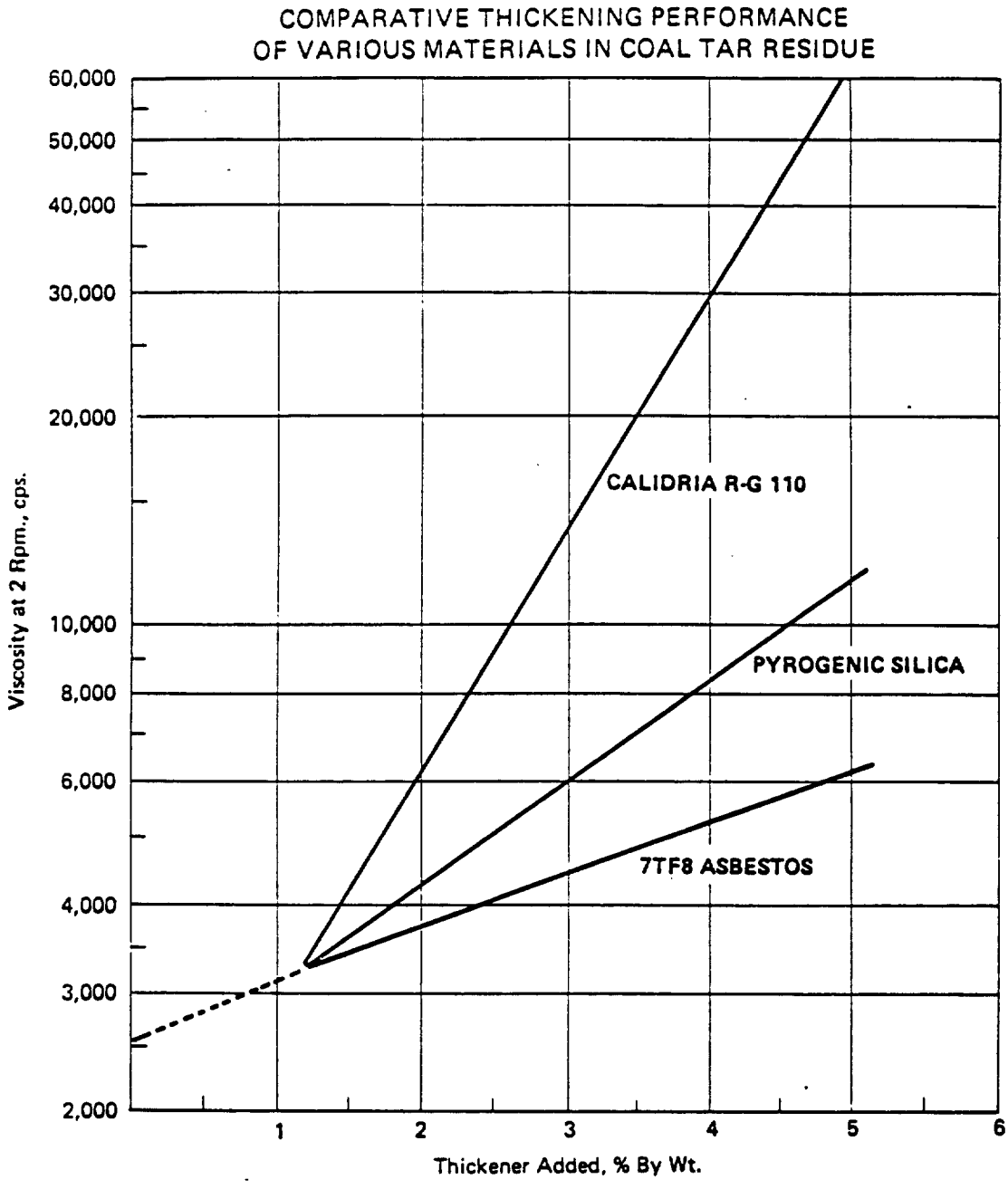


Fig. 13

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CALIDRIA R-G 144

Typical Physical Characteristics

Specific Gravity	2.45
Moisture Content, % by Wt.	2.0 max.
Surface Area, Sq. meters per gram	60 approx.
Reflectance, G.E. Brightness	72-76
Nature of Surface Charge	Electropositive (Cationic)
pH in Water (2% slurry)	9.0
Bulking Value, gal./100 lb.	4.8
Oil Absorption (DOP) lb./100 lb.	120
Refractive Index, n_d 25°C.	1.54-1.56
Aspect Ratio (Average L/D)	200:1
Tensile Strength, psi*	824,000 max. (281,000-436,000)
Tensile Modulus, psi*	23.2×10^6
Dry Bulk Density, lb./cu. ft. (fully aerated)	4

*1968 Modern Plastics Encyclopedia, p. 594

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Fig. 14

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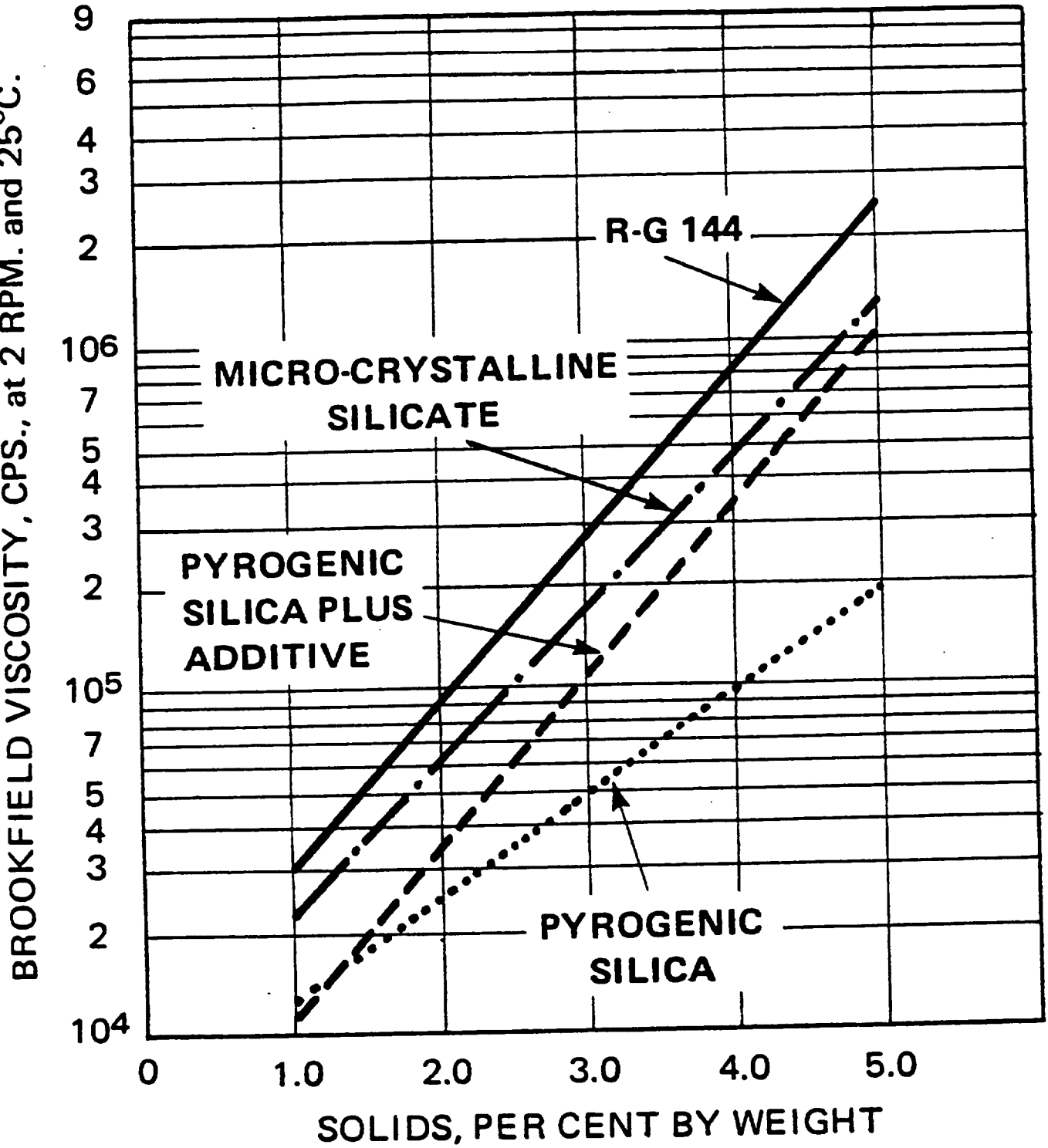
EPOXY ADHESIVES FOR PAVEMENT MARKERS

	Parts by Wt.
RAPID SET TYPE:	
Package A:	100.00
Epoxy Resin	3.00
RESIN-GRADE ASBESTOS	1.62
Titanium Dioxide	
Package B:	60.00
Polymercaptan Hardener	6.00
2,4,6-Tri(dimethylaminomethyl)phenol	15.00
Alkyl Subs. Polynuclear Aromatic Oil	0.20
2-Ethyl Hexanoic Acid	0.05
Carbon Black	2.00
RESIN-GRADE ASBESTOS	36.36
Glass Spheres	
STANDARD SET TYPE:	
Package A:	100.00
Epoxy Resin	7.31
Titanium Dioxide	5.00
RESIN-GRADE ASBESTOS	37.64
Talc	
Package B:	23.16
N-Aminoethyl Piperazine	52.00
Nonylphenol	0.22
Carbon Black	77.37
Talc	1.00
RESIN-GRADE ASBESTOS	

Fig. 15

A09772

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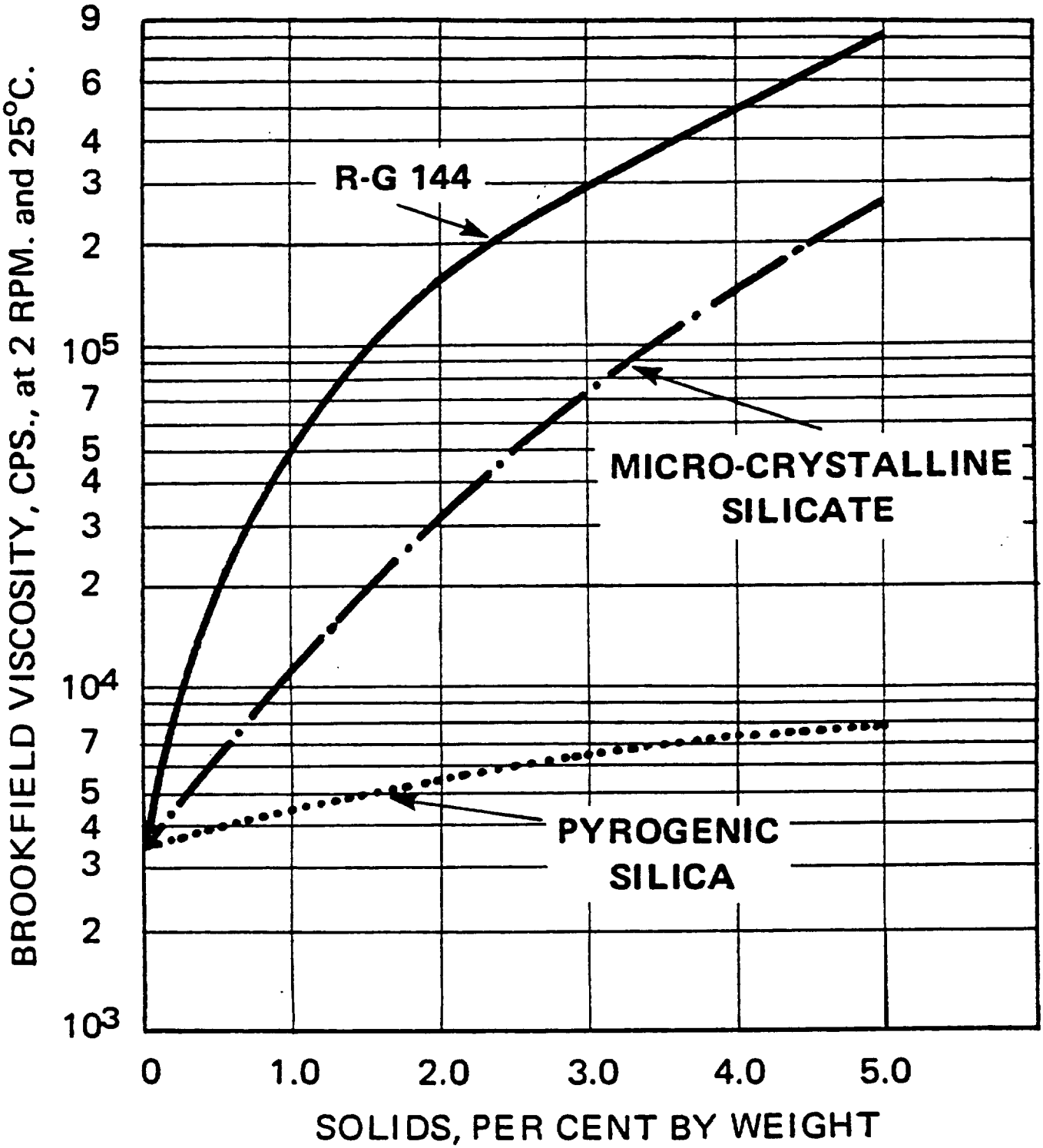


EFFECT ON VISCOSITY OF VARIOUS THICKENERS IN BAKELITE EPOXY RESIN ERL-2774

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Fig. 16

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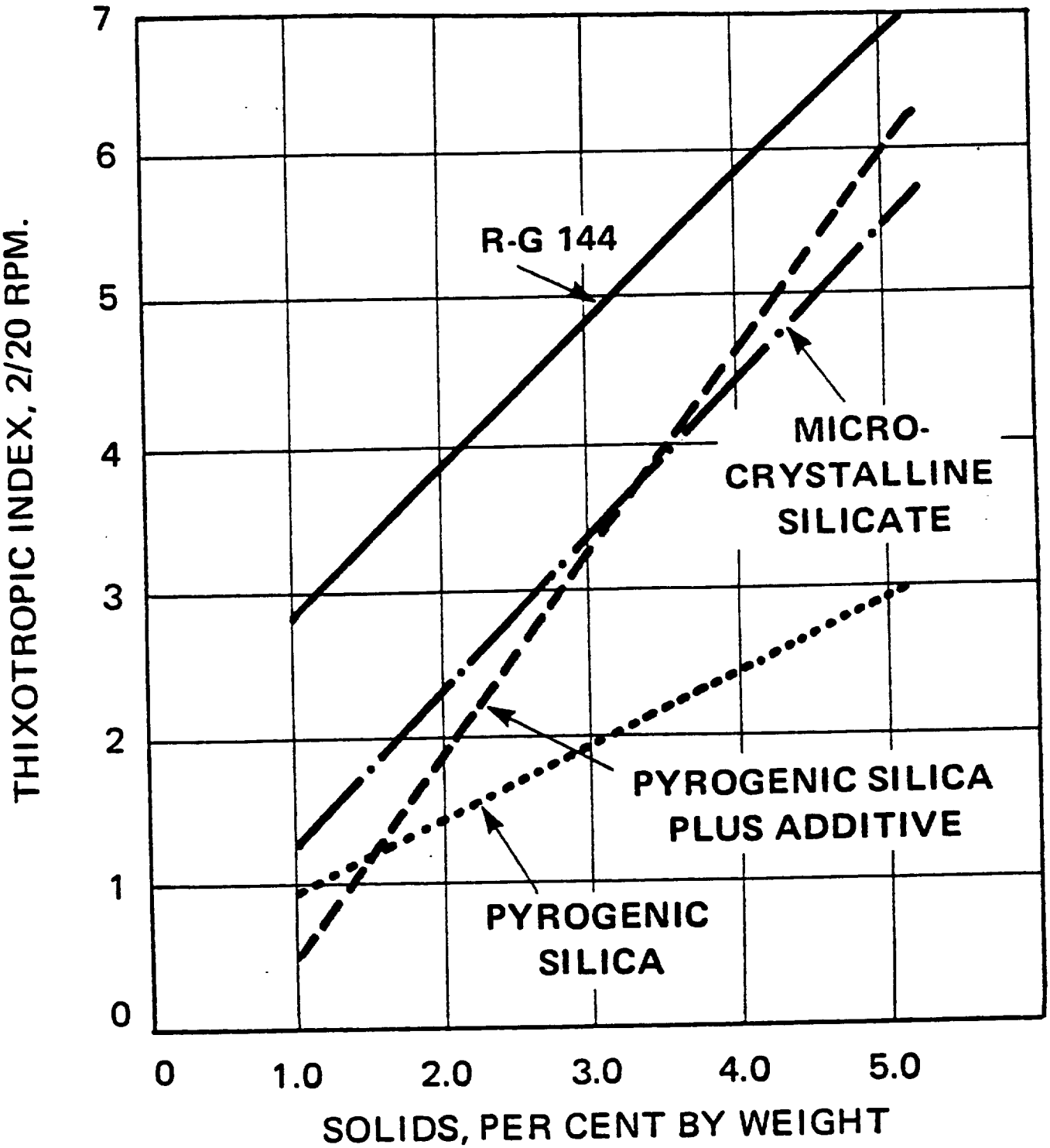


EFFECT ON VISCOSITY OF VARIOUS THICKENERS IN BAKELITE RESIN HARDENER ZZL-0814

A09774

Fig. 17

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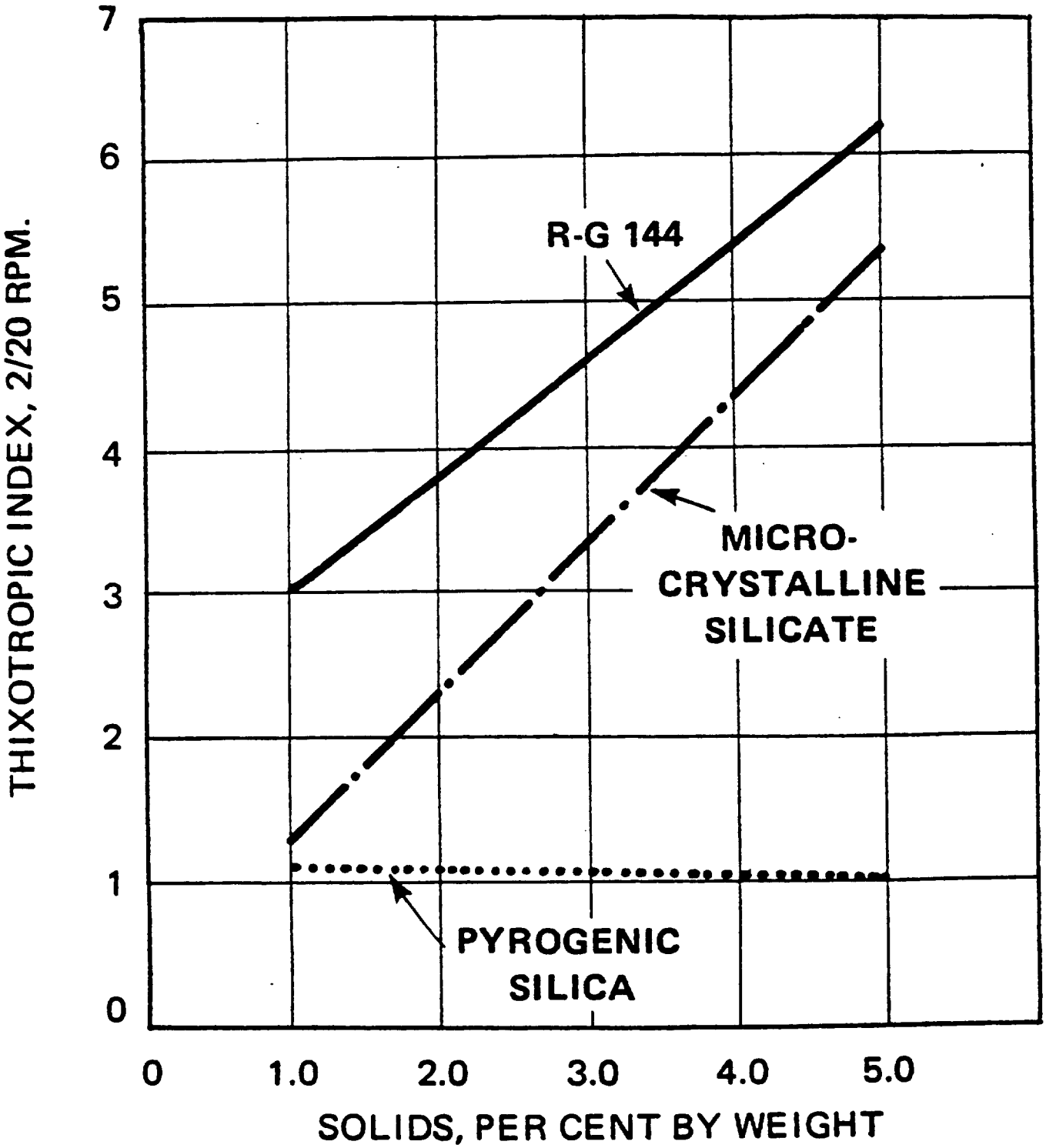


EFFECT ON THIXOTROPY OF VARIOUS THICKENERS IN
BAKELITE EPOXY RESIN ERL-2774

A09775

Fig. 18

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EFFECT ON THIXOTROPY OF VARIOUS THICKENERS IN
BAKELITE RESIN HARDENER ZZL-0814

A09776

Fig. 19

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Table 1 THICKENING OF BISPHENOL-BASED RESINS WITH *CALIDRIA* RESIN-GRADE 144 ASBESTOS

Ingredient	Parts by Weight											
BAKELITE ERL-2774 CALIDRIA Resin-Grade 144 Asbestos	100 1			100 2			100 3			100 4		
Brookfield RVF Viscosity, cps. X 10^{-3}	RPM. 2	RPM. 20	Thixotropic Index (T. I.) (a)	RPM. 2	RPM. 20	Thixotropic Index (T. I.)	RPM. 2	RPM. 20	Thixotropic Index (T. I.)	RPM. 2	RPM. 20	Thixotropic Index (T. I.)
24 hours	34	22	1.5	137	39	3.5	250	53	4.7	464	87	5.3
7 days	32	20	1.6	132	36	3.6	244	54	4.5	430	76	5.7
30 days	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	480	94	5.1
Vertical Drawdown, mil (c)												
Room Temperature	(b)			(b)			(b)			125		
45 days	(b)			(b)			(b)			125		

Ingredient	Parts by Weight											
BAKELITE ERL-2795 CALIDRIA Resin-Grade 144 Asbestos	100 1			100 2			100 3			100 4		
Brookfield RVF Viscosity, cps. X 10^{-3}	RPM. 2	RPM. 20	Thixotropic Index (T. I.)	RPM. 2	RPM. 20	Thixotropic Index (T. I.)	RPM. 2	RPM. 20	Thixotropic Index (T. I.)	RPM. 2	RPM. 20	Thixotropic Index (T. I.)
24 hours	18	3.8	4.7	38	6.3	6.0	70	11	6.4	91	13	6.9
7 days	16	3.7	4.3	35	6.8	5.1	68	12	5.5	122	22	5.5
30 days	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	125	25	5.0
Vertical Drawdown, mil (c)												
Room Temperature	(b)			(b)			(b)			80		
45 days	(b)			(b)			(b)			70		

(a) Thixotropic Index (T. I.) = $\frac{\text{viscosity at 2 rpm.}}{\text{viscosity at 20 rpm.}}$

(b) Not run.

(c) Vertical Drawdown: A 2-inch wide drawdown was made on a horizontal sandblasted steel panel. The panel was immediately raised to a vertical position and any sag noted. If no sag occurred in 10 minutes, the procedure was repeated and the thickness increased until sagging occurred.

Table 2 THICKENING OF AMINE HARDENERS WITH *CALIDRIA* RESIN-GRADE 144 ASBESTOS

Formulation	BAKELITE ZZL-0814 ...100 Parts by Wt. CALIDRIA Resin-Grade 144 Asbestos.....4			BAKELITE ZZL-0820.....100 Parts by Wt. CALIDRIA Resin-Grade 144 Asbestos.....4			BAKELITE ZZL-0854.....100 Parts by Wt. CALIDRIA Resin-Grade 144 Asbestos.....4		
Brookfield RVF Viscosity, cps. X 10^{-3}	RPM. 2	RPM. 20	Thixotropic Index (T. I.)	RPM. 2	RPM. 20	Thixotropic Index (T. I.)	RPM. 2	RPM. 20	Thixotropic Index (T. I.)
24 hours	187	36	5.3	67	32	2.1	102	23	4.5
7 days	172	34	5.1	66	32	2.1	104	23	4.6
30 days	177	34	5.2	67	35	1.9	104	24	4.4
Vertical Drawdown	Mil			Mil			Mil		
Room Temperature (R. T.)	70			40			40		
50°C.	20			—			—		
80°C.	—			40			40		
30 days at R. T.	70			40			40		
30 days at 80°C.	—			40			40		

A00777

REINFORCED VYNS-COMPRESSION MOLDED

	None	R-G 144	7RF9	7RO5
Tensile Strength, psi.	7600	9000	7700	7800
Tensile Modulus, 10^3 psi.	396	531	470	490
Elongation, %	2	3	16	6
Izod, ft-lb/in.	0.6	0.5	0.5	0.5
HDT, °C.	63.0	69.9	64.6	63.3
Color	Lt. Gray	Lt. Tan	Dk. Gray	Dk. Gray
Clarity	Clear	Clear	Opaque	Opaque

Formulation:

VYNS	100.00
Temex 5	1.20
Advastab CH-90	0.50
Advastab ABC-18	0.75
Stearic Acid	1.00
Asbestos	10.00

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Fig. 21

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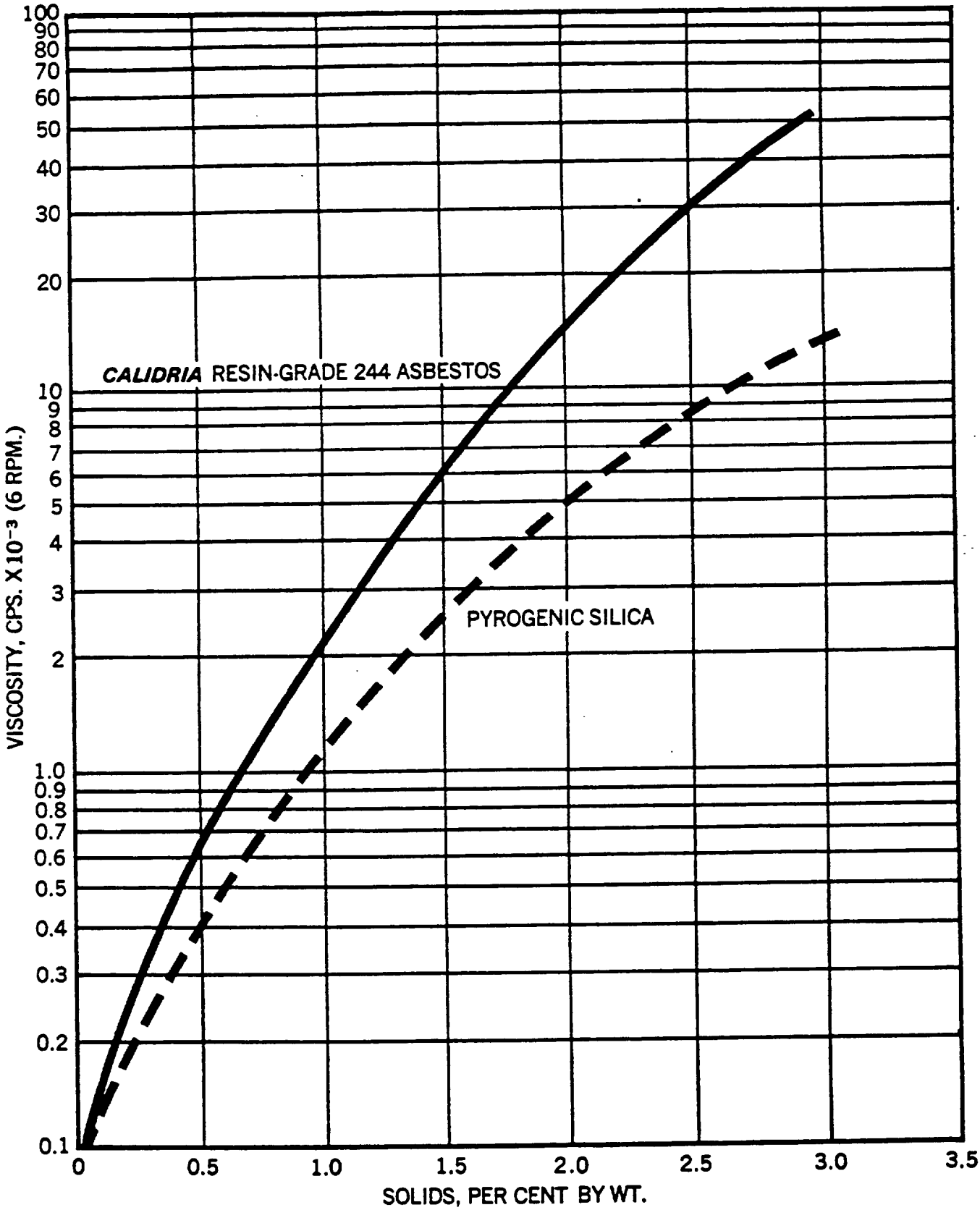
MECHANICAL PROPERTIES OF INJECTION MOLDED SAMPLES

	Phenoxy		P-1700 Polysulfone		Nylon-6	
	0% R-G 144	20% R-G 144	0% R-G 144	15% R-G 144	0% R-G 144	30% R-G 144
Tensile Strength, psi.	9250	18000	10000	14000	9000	20000
Tensile Modulus, 10^3 psi.	470	1070	370	850	-	-
Flexural Strength, psi.	-	-	-	-	11000	30000
Flexural Modulus, 10^3 psi.	-	-	-	-	260	1500
Elongation, % at yield	4.7	3.5	5.7	3.9	4.0	4.1
Izod, ft-lbs./in.	2.3	0.6	1.2	1.2	1.3	0.9
HDT, ^oC.	86.5	88.8	170	180	58	196

Fig. 22

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Comparison of Thickening Efficiency of Resin-Grade 244 Asbestos with that of Colloidal Silica in Polyester Resin

Fig. 23

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TYPICAL HEAT-CURABLE VINYL SEALANT FORMULATION

Ingredient	Per Cent by Weight
BAKELITE Vinyl Dispersion Resin QYLF-2	24.54
BAKELITE Vinyl Resin Solution VMCC	3.92
"Elvacite" 2044(a)	0.98
"Hycar" 1411(b)	0.37
"Camel White"(c)	29.20
FLEXOL Plasticizer 10-10	29.20
FLEXOL Plasticizer TCP	2.70
"Monomer X-970"(d)	4.91
"Mark" LL(e)	0.49
Resin-Grade 244 Asbestos	3.68
"Dicup" R(f)	0.01
	100.00

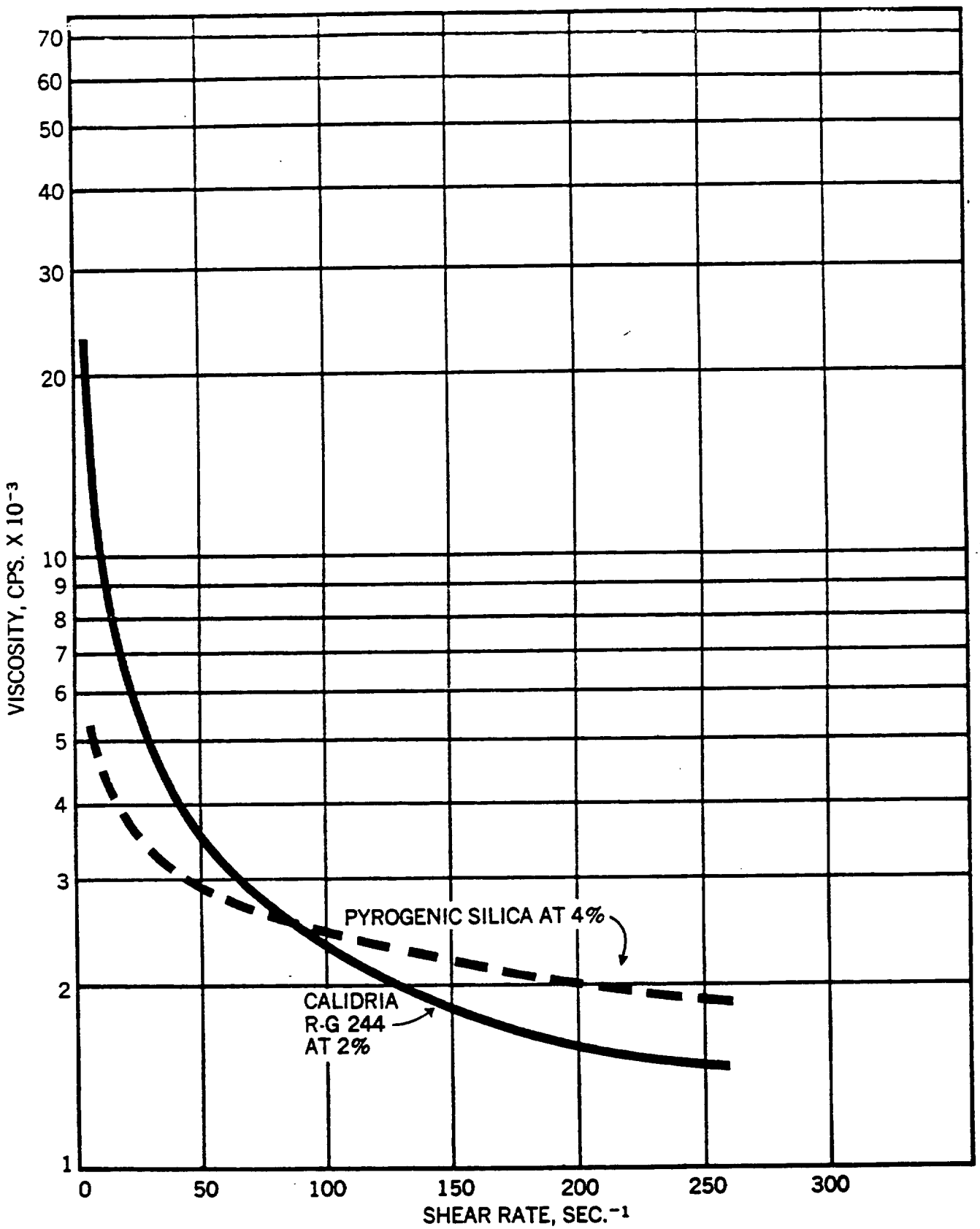
.Dissolve BAKELITE Vinyl Resin Solution VMCC in FLEXOL Plasticizer 10-10 at about 100°C. Dissolve "Elvacite" 2044 in FLEXOL Plasticizer TCP at 100°C. Mix the two solutions and all the other ingredients together in a pony, "Hobart" or similar mixer.

(a) Acrylic resin; Du Pont, Wilmington, Delaware
(b) Powdered rubber; B. F. Goodrich, Akron, Ohio
(c) Calcium carbonate; H. T. Campbell and Son's Corporation, Baltimore, Maryland
(d) Polymerizable monomer; Rohm and Haas, Philadelphia, Pennsylvania
(e) Stabilizer; Argus Chemical Corporation, Brooklyn, New York
(f) Catalyst; Hercules, Wilmington, Delaware

Fig. 24

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Comparative Thixotropic Characteristics CALIDRIA R-G 244 Vs Pyrogenic Silica

A09782

Fig. 25

STATUS SUMMARY - MID 1970

ASBESTOS TOXICOLOGY

CALIDRIA ASBESTOS
UNION CARBIDE CORPORATION
P.O.BOX 579
NIAGARA FALLS, N.Y. 14302

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INTRODUCTION

Over the past several years a great deal has been said in the public press regarding the potential health hazards of asbestos. Much of this has been based on a classic work of environmental medicine by Dr. Irving J. Selikoff now at the Mt. Sinai School of Medicine in New York City. Although Dr. Selikoff's work covered only a single end use, sprayed asbestos for the insulation of steel frame buildings, it has been extrapolated and interpreted by others to give a widely held impression that asbestos is an extremely dangerous material. This report is intended to provide some of the most recent information on this subject so that objective judgments may be made.

CONCLUSIONS

These references lead to the conclusion that there is a hazard in the use of asbestos. As the McGill study points out, however, even under poorly controlled dust conditions ..."the total number of respiratory diseases attributable to asbestos was very small." Asbestos thus appears to be a typical industrial raw material, i.e., it has some handling hazards but can be used safely as long as reasonable care is exercised. There are explicit government specifications on allowable dust levels that constitute safe handling.

The Union Carbide Corporation Industrial Medicine and Toxicology Department has prepared a more detailed summary of the current state of knowledge on asbestos toxicology. It is attached for reference.

A09784

EXPERIENCE WITH SPRAYED ASBESTOS IN THE BUILDING TRADES

A synopsis of Dr. Selikoff's latest thinking is given in an article in the Engineering News Record of April 2, 1970. A copy of this article is attached for reference with the following quotations particularly pertinent here:

> "From buildings under construction there is often a gentle floating fall of a cottony material. This material that fails to adhere to the steel as it should and blows up, down, around and across a job and sometimes over wide sections of a city on windy days."

> "The resulting storm of asbestos dust is a potential danger to everyone on the job, according to Dr. Selikoff. He has not as yet gathered extensive data on the threat to the general public and will not guess the possible incidence of asbestosis or lung cancer among those not directly working with asbestos but intermittently exposed to it in a casual way."

> "Dr. Selikoff says that products in which asbestos has been bonded into the material, such as floor and ceiling tiles, roofing, siding, and pipe, are not considered a cause of cancer."

This position is also amplified by the following additional quotations of Dr. Selikoff from another source.(1)

SELIKOFF

> Of the eighty-seven men who didn't smoke cigarettes, we didn't expect any to die of lung cancer, because people who don't smoke cigarettes by and large don't die of lung cancer, although a few do. That has been our experience among the asbestos workers as well. We have yet to see in New York City a death due to lung cancer in an asbestos worker who didn't smoke cigarettes. On the other hand, of the two hundred and eighty-three men who had a history of cigarette smoking, we should have expected, as cigarette smokers, two or three deaths due to lung cancer. There have

(1) Men and Molecules, American Chemical Society News Service, 1155 Sixteenth St. N.W., Washington, D.C. 20036

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been twenty-seven. This indicates that there is some combined multiple effect between asbestos and lung cancer. Dr. Hammond has calculated that an asbestos worker who smokes cigarettes has ninety-two times the risk of dying of lung cancer as compared with a person who neither works with asbestos, nor smokes cigarettes. Therefore, if asbestos workers will stop smoking cigarettes, and many have, we can probably eliminate a large part of the risk of lung cancer among them.

NARRATOR

Unfortunately, at this point, there is no simple way to reduce the other possible result of working with asbestos--the appearance, twenty-five to thirty years after the fact, of mesothelioma, the cancer of lung and abdominal tissue, that is now a fatal and virtually incurable disease.

SELIKOFF

We have observed mesothelioma among asbestos workers who do not smoke cigarettes. Therefore, a second approach is necessary: the approach of sharply decreasing the exposure to asbestos. Now, most of these men began work, and were exposed to asbestos, at a time when the risk was not known. Therefore, precautions were either minimal or nonexistent. We now know these risks, and, therefore, it is important for us to design measures, knowing these risks, to eliminate them.

It is important to note that Dr. Selikoff worked with men who generally had extended exposure to generally high levels of asbestos. This leading medical expert in the field is advocating that asbestos be handled with reasonable care, not that it be banned.

EXPERIENCE IN ASBESTOS MILLS AND GENERAL ENVIRONMENT

The most recent information in this area was reported in the magazine Asbestos in May 1970. A copy of this article is attached for reference. The results of a three-year survey by a research team from the medical faculty of McGill University provides the following key information:

A09786

> "...at present levels of dust exposure in modern asbestos mills, even 30 years' employment would probably not carry any measurable risk of lung cancer."

> "Two points must be emphasized," declared Dr. McDonald. "First that the dust exposure experienced by these workers occurred many years ago when environmental conditions in the asbestos mills were poorly controlled and second, that the total number of respiratory diseases attributable to asbestos was very small."

> "The two sets of results confirm the association between occupational exposure to asbestos and these two varieties of respiratory cancer. The results are nevertheless encouraging in that they suggest the risk is virtually confined to levels of dust exposure which are controllable, if not already controlled, in most Canadian asbestos mines and mills."

Perhaps the most significant aspect of this work is the finding that:

> "There was no increased number of cases whose contact was limited to residence in the neighborhood of asbestos mines or mills."

It is noteworthy that these workers also find that additional factors beyond asbestos are probably involved in mesothelioma.

> "Close surveillance over the occurrence of suspected mesotheliomas in Canada, so as to better understand their cause. Asbestos exposure has failed to explain most of them and is probably not the only factor when present." Dr. McDonald commented.

ACTION BY THE U.S. GOVERNMENT

Allowable levels of industrial dusts have long been controlled by the Federal and State governments. The latest thinking has been incorporated into the Walsh-Healy Public Contracts Act which went into effect on February 17, 1969. A copy is attached.

This Act reduces the allowable level of asbestos dust from 5 to 2 million particles per cubic foot. Although it has been generally

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accepted that a worker will not develop asbestosis if he is exposed to no more than 5 million particles per cubic foot of air, even if the exposure continues for his entire working lifetime, the reduction in allowable limit represents an effort to increase the safety factor.

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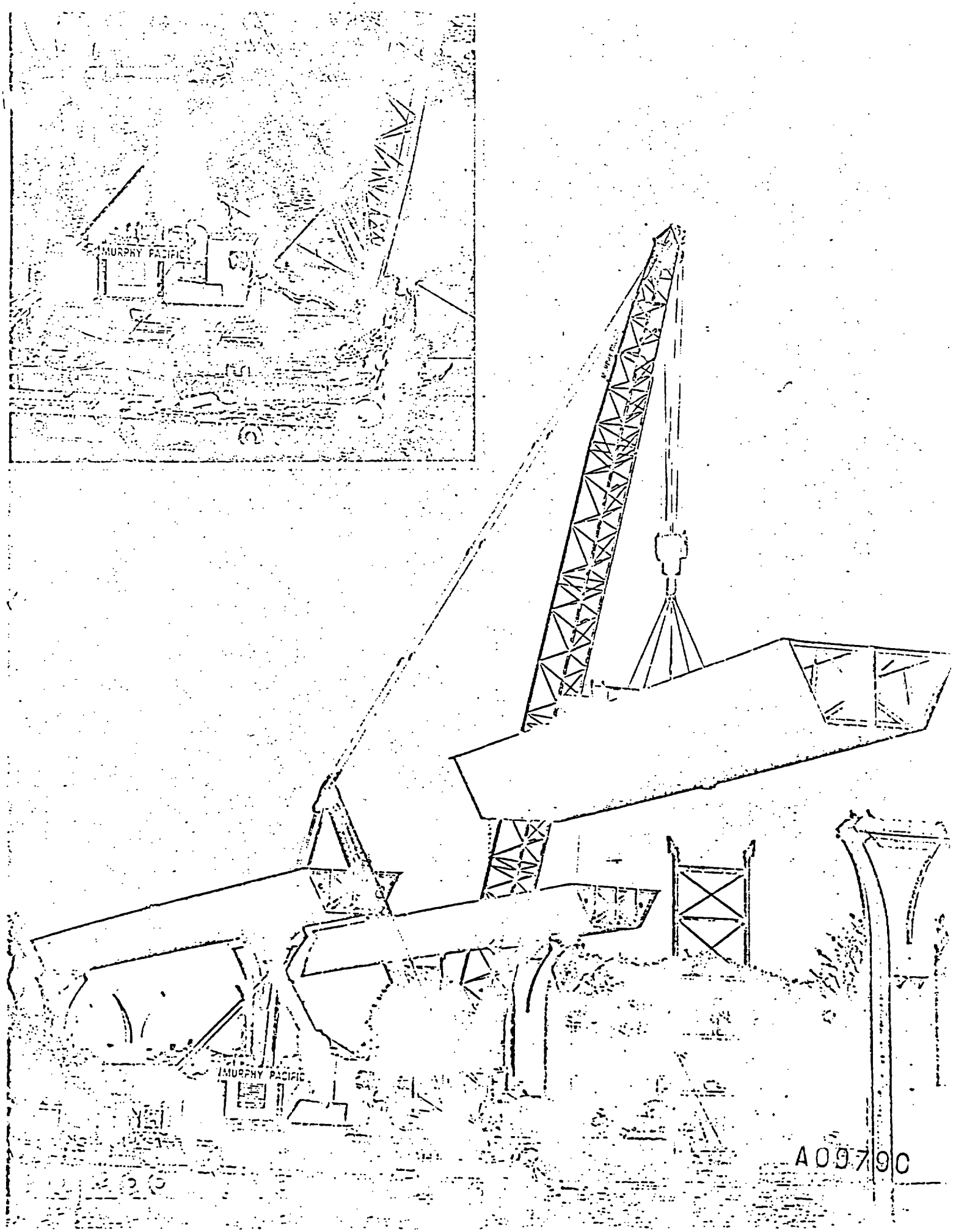
Engineering News-Record
McGRAW-HILL'S CONSTRUCTION WEEKLY
APRIL 2 1970 / 75¢

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APR 10 1970

Does sprayed asbestos cause lung cancer?

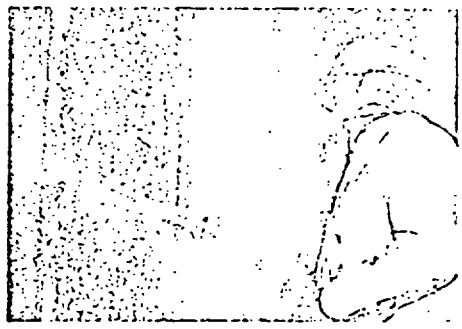
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Loose asbestos fiber seen as cancer threat to men in building trades



Medical researchers have found strong evidence that sprayed asbestos used in fireproofing steel-framed buildings causes cancer in men who work on these buildings.

The hazards of asbestos are becoming a public issue. New York City is considering regulating its use and a California legislator introduced a bill this year to prohibit installation of asbestos inside air duct systems in public buildings. So far, however, no positive legislative action to control its use or method of application has been enacted.

The most likely victims are the men who spray the asbestos mixture on exposed steel members and ductwork and apparently inhaled the heaviest amounts of asbestos fiber.

Once asbestos fibers enter the pulmonary or gastro-intestinal tract, they never leave the body, never break down. Medical research is making an increasingly strong case against these fibers as a source of cancer.

The asbestos fibers and dust particles, those highly visible during a spraying operation and the millions of microscopic ones, also cause asbestosis, which is associated with lung cancer.

Three physicians have statistically tied asbestos to cancer among workers in or closely allied to the building trades. They are: Dr. Irving J. Selikoff, director of the Division of Environmental Medicine at Mt. Sinai Hospital, in New York City; Dr. Jacob Churg, chief pathologist at Barnert Memorial Hospital, of Paterson, N.J.; and Dr. E. Cuyler Hammond, vice president for epidemiology and statistics of the American Cancer Society.

In 1962 they compiled a list of 632 men who, as of Dec. 31, 1942, had been members of two metropolitan New York City locals of the International Association of Heat and Frost Insulators and Asbestos Workers (IAHFIAW), AFL-CIO, and who had been exposed to asbestos for 20 years or more. Union, medical and insurance records showed that in the 1932-1962 period, 262 out of the 632 had died, seven before 20 years of exposure. On the basis of ages of the study group, the normal death total should have been 203.

Moreover, 45 died of lung cancer, when actuarial tables anticipated only six. And another 50 deaths resulted from other types of cancer. Of this number, 29 died of gastro-intestinal cancer, although only 10 would have been the normal number for this disease.

Still working with the original list, Dr. Selikoff later found that between January, 1963, and March, 1963, of the 370 survivors of the original 632 men, 113 more had died, while standard mortality tables would predict only 50 deaths. Of the 113 deaths, 28 were caused by cancer in the pulmonary tract, eight by gastro-intestinal cancers and 15 from asbestosis, which is a build-up of scar tissue in the lungs resulting from the presence of asbestos particles.

The scarring impairs the lungs so severely that they cannot absorb sufficient oxygen. There is no cure. Death, a strangulating, coughing demise, is the only end.

Dr. Selikoff says that products in which asbestos has been bonded into the material, such as floor and ceiling tiles, roofing, siding and pipe, are not considered a cause of cancer.

The data that scares. The data disclosed by Dr. Selikoff pushed the New York City Department of Air Resources into a start on writing regulations that would regulate the spray application of asbestos for both fireproofing and insulation.

The regulations would require: Before insulating and fireproofing material is applied, the entire floor of the area involved in the operation be cleared of all objects, materials and equipment except that needed to apply the material.

- As the material falls to the floor, fragments be swept up immediately and placed in special containers.
- Wet sweeping of the area, and vacuuming to pick up the material that had dried.
- Enclosure tarpaulins not be dismantled for 24 hours after completion of clean-up unless adequate mechanical means are provided to clean the air within the enclosed area.

Great Britain already has strict regulation of sprayed asbestos fireproofing (see box).

Richard L. Ottinger, a Democratic member of the House of Representatives from Westchester County, N.Y., last week latched on to the sprayed-asbestos operation as an environmental issue with political appeal.

Ottinger, a cosponsor of the federal Air Quality Act of 1967, charges that New Yorkers are exposed to tons of cancer-causing asbestos dust every year. He specifically cites the sprayed-asbestos method of fireproofing buildings and demands that the federal government impose regulations governing the use of asbestos.

He says the federal Air Pollution Control Administration can act now under authority already provided by the Air Quality Act.

The apparent virulence of asbestos is more than a table of death rates to Ottinger. Five years ago it struck at Mike Kitzmiller, now Ottinger's legislative aide. When Kitzmiller was making repairs on his house, some loose asbestos insulation fell into an open cut on his shoulder.

The cut healed, but one year later the scar developed a "mean-looking dark area around it," according to Kitzmiller. By last summer, the scar became painful. Tests showed it was malignant. Surgery removed the cancer.

Hitting the obvious. Ottinger, now seeking the Democratic nomination for U.S. senator from New York, was calling attention to a phenomenon seen by

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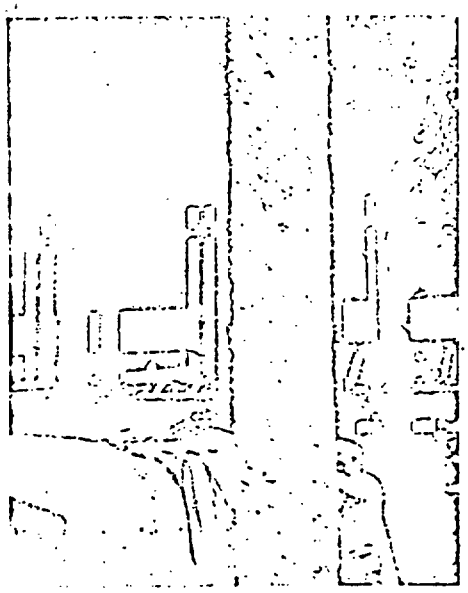
many persons in cities across the country, but understood by a relatively small number. From buildings under construction there is often a gentle floating fall of a cottony material. This is material that fails to adhere to the steel as it should and blows up, down, around and across a job and sometimes over wide sections of a city on windy days.

The fireproofing material is a mixture of asbestos, rock wool and cement. It is contained on the job in a cone-shaped hopper equipped with a worm gear at the bottom that feeds the mix into a hose. Compressed air, at about 22 psi, pushes it through the hose to a nozzle. Approximately 1 in. beyond the nozzle's end, the dry asbestos-rock wool-cement mix interacts with a stream of water running through a second hose.

The wet fireproofing material then is sprayed directly against the steel members previously hosed down with water to improve bonding.

About 200 tons of sprayed fiber material is used on a 30-story building. Depending on weather conditions and measures taken to provide some enclosure, as much as 50% of the sprayed material may be wasted.

The resulting storm of asbestos dust is a potential danger to everyone on the job, according to Dr. Selikoff. He has not as yet gathered extensive data on the threat to the general public and will not guess the possible incidence of asbestosis or lung cancer among those not directly working with asbestos but intermittently exposed to it in a casual way.



Asbestos airborne is source of worry.

The helping hands. Dr. Selikoff has received support from the insulators and asbestos workers international union since mid-1950. The union first provided the health histories of its members. Then in October, 1968, Johns-Manville Corp., of New York City, the largest producer of asbestos in this country, joined with the international union in backing Dr. Selikoff's work with cash. The company and the union provided $362,500 to finance a new program called the Insulation Industry Hygiene Research Program (IIHRP). Dr. Selikoff directs the program out of Mt. Sinai Hospital.

IIHRP's primary purpose is to develop methods of minimizing exposure of all insulation workers to dust and fumes encountered on the job.

The program has already had some repercussions. Chief among them is the sprayed asbestos fireproofing operation at the twin 110-story towers of the World Trade Center in New York City. On this job, which will require an estimated 5,000 tons of sprayed fireproofing, specially designed tarpaulins cover the exterior of the floors being fireproofed. The tarps extend through the window openings and are tucked back under the sprandrels so that material being sprayed will not escape from the area and fall on other floors, or surrounding streets. Moreover, the area being sprayed is closed off inside the building with plastic sheeting so that the materials will not drift into adjacent work areas.

New York City has also taken an initial step by preparing rules to control the application of sprayed-asbestos fireproofing. But the regulations have not gone much further than an initial draft since the city's Environmental Protection Administration and the Department of Air Resources have not had commissioners at the helm for several weeks. The rules, therefore, have not been pushed.

As proposed the regulations would require that sprayed asbestos fireproofing contractors obtain a license. In addition, the area of a building being sprayed would be tightly sealed, the precautions approximating, and in some cases, exceeding those now in effect at the $600-million World Trade Center project.

Should such regulations ever become effective, they would raise costs of fireproofing with sprayed asbestos. A structural engineer reports the costs now range between 30 cents and 60 cents a sq ft.

And another broad estimate came from Mario & DiBonno Plastering Co., Inc., of Great Neck, N.Y., which said the approximate cost of fireproofing a 30-story building is $250,000.

One of the five major companies that make the spray-asbestos material has sought and succeeded in developing a spray-on fireproofing compound that contains no asbestos. The manufacturer, U.S. Mineral Products Co., of Stanhope, N.J., said that the new product, Cafco Type D-C/F, will be on the market in about a month.

It contains mineral wool and proprietary binders it will not identify. It will cost about 10% more than spray-on asbestos fireproofing material.

Company officials say that they developed the new material because of the controversy starting to develop over asbestos.

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Great Britain restricts asbestos spraying

The United Kingdom, with extensive statistical material linking asbestos to cancer, only last year cracked down on the use of asbestos in the building trades.

The thorough, detailed and apparently restrictive regulations have all but eliminated asbestos-spray fireproofing as a method, according to an officer in the National Federation of Plastering Contractors. He says that instead of using sprayed asbestos as the fireproofing agent, contractors are boxing asbestos panels around the structural members.

The regulations require:

- Filing by the contractor of an application with the Department of Employment and Productivity 28 days before asbestos is to be applied on a structure.
- Operation of exhaust and ventilating equipment in the area of asbestos application.
- Mandatory use of respirators by workers in asbestos-contaminated areas, and wearing of special clothing. The mask and clothing must be provided by the contractor.
- Storage of asbestos in "suitable containers," marked with blue paint or ink, "asbestos–do not inhale."
- Vacuuming of all surfaces, machines and equipment in areas where asbestos is applied.

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THE INFLUENCE OF ASBESTOS ON HEALTH

Three-Year Survey

The results of a three-year survey by a research team from the Medical Faculty of McGill University into the health of workers in Quebec's asbestos mining industry suggest that, at present levels of dust exposure in modern asbestos mills, even 20 years employment would probably not carry any measurable risk of lung cancer.

The influence of asbestos on health has been the subject of intensive research in many parts of the world mainly because of the discovery that, in certain circumstances, exposure to the mineral fiber may be related to cancer of the lung and to mesothelioma, a cancer of the covering of the lung.

Supported by substantial grants from the Institute of Occupational and Environmental Health of the Quebec Asbestos Mining Association as well as from the U.S. Public Health Service, the epidemiological studies formed part of an international research program coordinated by the Union Internationale Contre le Cancer.

Headed by Dr. J. C. McDonald, of McGill University's Department of Epidemiology and Health, the international research team's investigations were aimed at assessing the risks of lung cancer to persons exposed to Canadian Chrysotile asbestos. Another primary purpose was to review all aspects of the health of workers in Quebec's asbestos mines and mills to ensure that it is efficiently protected.

Dr. McDonald reported on the findings of a study of mortality and causes of death in some 12,000 industry employees born between 1890 and 1920. The survey showed that the 10% of these employees who belonged to the highest dust-exposure group had an overall death rate about 12% higher than the others, mainly due to asbestosis, lung cancer and other respiratory complaints. The lung cancer death rate in this same group was about three times higher than that of employees with minimal dust exposure. Seventy per cent of this group of employees who belonged to the lowest dust-exposure categories had little or no increased mortality from these diseases.

"Two points must be emphasized," declared Dr. McDonald. "First, that the dust exposure experienced by these workers occurred many years ago when environmental con-

ditions in the asbestos mills were poorly controlled, and, second, that the total number of respiratory diseases attributable to asbestos was very small.

Dr. McDonald then reported on the results of findings from surveys throughout Canada of deaths due to mesothelioma. During the 1960-63 period only 165 fatal cases had been recorded by pathologists throughout the entire country. Field inquiries confirmed that in a minority of cases there was a definite history of having worked with asbestos. Almost all the histories were of exposure in the manufacture and industrial application of the mineral, rather than in the production of asbestos fiber. There was no increased number of cases whose contact was limited to residence in the neighborhood of asbestos mines or mills.

The two sets of results confirm the association between occupational exposure to asbestos and these two varieties of respiratory cancer. The results are nevertheless encouraging in that they suggest the risk is virtually confined to levels of dust exposure which are controllable, if not already controlled, in most Canadian asbestos mines and mills.

In light of the researchers' findings, it has been decided to continue the research program, with Asbestos Industry support, for a further five years. The extended research program into the health of Quebec's 6,000 asbestos workers will have these main objectives:

(1) To record and analyze deaths and their cause to enable the present approximate estimation of what constitutes a safe level of dust concentration to be more accurately defined.

(2) Close surveillance over the occurrence of suspected mesotheliomas in Canada, so as better to understand their cause. "Asbestos exposure has failed to explain most of them and is probably not the only factor when present," Dr. McDonald commented.

(3) In collaboration with the Industry's industrial clinics in Thetford Mines and Asbestos, it is planned to introduce new procedures for the regular periodic medical supervision of asbestos workers, based on the lessons learned during the three-year study just completed.

DECISION-MAKING SYMPOSIUM—The 9th International Symposium on *Techniques for Decision Making in the Mineral Industry* will be held in Montreal, Canada, June 14-19, 1970.

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Title 41—PUBLIC CONTRACTS AND PROPERTY MANAGEMENT

Chapter 50—Public Contracts, Department of Labor

PART 50–201—GENERAL REGULATIONS

PART 50–204—SAFETY AND HEALTH STANDARDS FOR FEDERAL SUPPLY CONTRACTS

Safety and Health Standards

On November 6, 7, and 8, 1968, interested persons were afforded an opportunity to submit orally data, views, and arguments on proposals to revise Part 50–204 of Title 41, Code of Federal Regulations, and section 50–201.502 of that title published in the FEDERAL REGISTER on September 20, 1968 (33 F.R. 14253). Interested persons were also afforded an opportunity to submit written data, views, and arguments concerning the proposals.

After consideration of all such relevant matter as was presented by interested persons, Part 50–204 and § 50–201.502 are hereby revised as indicated below. The revised § 50–204.36 republishes the radiation standards for mining published in the FEDERAL REGISTER on December 28, 1968 (33 F.R. 19947), which are presently in effect.

The revisions shall become effective 30 days following the date of publication in the FEDERAL REGISTER.

1. Part 50–204 is revised to read as follows:

Subpart A—Scope and Application

Sec.
50–204.1 Scope and application.

Subpart B—General Safety and Health Standards

50–204.2 General safety and health standards; incorporation by reference.
50–204.3 Material handling and storage.
50–204.4 Tools and equipment.
50–204.5 Machine guarding.
50–204.6 Medical services and first aid.
50–204.7 Personal protective equipment.
50–204.8 Use of compressed air.
50–204.10 Occupational noise exposure.

Subpart C—Radiation Standards

50–204.20 Radiation—Definitions.
50–204.21 Exposure of individuals to radiation in restricted areas.
50–204.22 Exposure to airborne radioactive material.
50–204.23 Precautionary procedures and personnel monitoring.
50–204.24 Caution signs, labels and signals.
50–204.25 Exceptions from posting requirements.
50–204.26 Exemptions for radioactive materials packaged for shipment.
50–204.27 Instruction of personnel posting.
50–204.28 Storage of radioactive materials.
50–204.29 Waste disposal.
50–204.30 Notification of incidents.
50–204.31 Reports of overexposure and excessive levels and concentrations.
50–204.32 Records.
50–204.33 Disclosure to former employee of individual employee's record.
50–204.34 AEC licensees—AEC contractors operating AEC plants and facilities—AEC-agreement State licensees or registrants.
50–204.35 Application for variation from radiation levels.
50–204.36 Radiation standards for mining.

Subpart D—Gases, Vapors, Fumes, Dusts, and Mists

50–204.50 Gases, vapors, fumes, dusts, and mists.
50–204.65 Inspection of compressed gas cylinders.
50–204.66 Acetylene.
50–204.67 Oxygen.
50–204.68 Hydrogen.
50–204.69 Nitrous oxide.
50–204.70 Compressed gases.
50–204.71 Safety relief devices for compressed gas containers.
50–204.72 Safe practices for welding and cutting on containers which have held combustibles.

Subpart E—Transportation Safety

50–204.75 Transportation safety.

Subpart F—Variations

50–204.80 Variations.

AUTHORITY: The provisions of this Part 50–204 issued under secs. 1, 4, 49 Stat. 2036, 2038, as amended; 41 U.S.C. 35, 38; 5 U.S.C. 556.

Subpart A—Scope and Application

§ 50–204.1 Scope and Application.

(a) The Walsh-Healey Public Contracts Act requires that contracts entered into by any agency of the United States for the manufacture or furnishing of materials, supplies, articles, and equipment in any amount exceeding $10,000 must contain, among other provisions, a stipulation that "no part of such contract will be performed nor will any of the materials, supplies, articles, or equipment to be manufactured or furnished under said contract be manufactured or fabricated in any plants, factories, buildings, or surroundings or under working conditions which are unsanitary or hazardous or dangerous to the health and safety of employees engaged in the performance of said contract" (sec. 1(c), 49 Stat. 2036, 41 U.S.C. 35(c)). This Part 50–204 expresses the Secretary of Labor's interpretation and application of this provision with regard to certain particular working conditions. In addition, §§ 50–204.27, 50–204.30, 50–204.31, 50–204.32, 50–204.33, and 50–204.36 contain requirements concerning the instruction of personnel, notification of incidents, reports of exposures, and maintenance and disclosure of records.

(b) Except in the conduct of formal enforcement proceedings provided for in Part 50–203 of this chapter and as otherwise provided in this part, every investigator conducting investigations and every officer of the Department of Labor determining whether there are or have been violations of the safety and health requirements of the Walsh-Healey Public Contracts Act and of any contract subject thereto, and whether a settlement of the resulting issues should be made without resort to administrative or court litigation, shall treat a failure to comply with, or violation of, any of the safety and health measures contained in this Part 50–204 as resulting in working conditions which are "unsanitary or hazardous or dangerous to the health and safety of employees" within the meaning of section 1(c) of the Act and the contract stipulation it requires. Every such investigator or every such officer shall have technical competence in safety, industrial hygiene, or both as may be appropriate, in the matters under investigation or consideration.

(c) Whenever any applicable standard in this Part 50–204 is relied upon by the Department of Labor in a formal enforcement proceeding under section 5 of the Walsh-Healey Public Contracts Act to support a finding of violation of the safety and health provisions of the Act and of a contract subject thereto, any respondent in the proceeding shall have the right and shall be afforded the opportunity to challenge the legality, fairness or propriety of any such reliance.

(d) The standards expressed in this Part 50–204 are for application to ordinary employment situations; compliance with them shall not relieve anyone from the obligation to provide protection for the health and safety of his employees in unusual employment situations. Neither do such standards purport to describe all of the working conditions which are unsanitary or hazardous or dangerous to the health and safety of employees. Where such other working conditions may be found to be unsanitary or hazardous or dangerous to the health and safety of employees, professionally accepted safety and health practices will be used.

(e) Compliance with the standards expressed in this Part 50–204 is not intended, and shall not be deemed, to relieve anyone from any other obligation he may have to protect the health and safety of his employees, arising from sources other than the Walsh-Healey Public Contracts Act, such as State, local law or collective bargaining agreement.

(f) Whenever this part adopts by reference standards, specifications and codes published and available elsewhere, it only serves to adopt the substantive, technical portions of such standards, specifications and codes.

Subpart B—General Safety and Health Standards

§ 50–204.2 General safety and health standards; incorporation by reference.

(a) Every contractor shall protect the safety and health of his employees by complying with the applicable standards, specifications, and codes developed and published by the following organizations:

United States of America Standards Institute (American Standards Association).
National Fire Protection Association.
American Society of Mechanical Engineers.
American Society for Testing and Materials.
United States Governmental Agencies, including by way of illustration the following publications of the indicated agencies:

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(1) *Atomic Energy Act Sources.* Any employer who possesses or uses source material, byproduct material, or special nuclear material, as defined in the Atomic Energy Act of 1954, as amended (42 U.S.C. 2011 et seq.), and has either registered such sources with, or is operating under a license issued by, a State which has an agreement in effect with the Atomic Energy Commission pursuant to section 274(b) (42 U.S.C. 2021(b)) of the Atomic Energy Act of 1954, as amended, and in accordance with the requirements of that State's laws and regulations shall be deemed to be in compliance with the radiation requirements of this part, insofar as his possession and use of such material is concerned, unless the Secretary of Labor, after conference with the Atomic Energy Commission, shall determine that the State's program for control of these radiation sources is incompatible with the requirements of this part. Such agreements currently are in effect only in the States of Alabama, Arkansas, California, Kansas, Kentucky, Florida, Mississippi, New Hampshire, New York, North Carolina, Texas, Tennessee, Oregon, Idaho, Arizona, Colorado, Louisiana, Nebraska, and Washington.

(2) *Other sources.* Any employer who possesses or uses radiation sources other than source material, byproduct material, or special nuclear material, as defined in the Atomic Energy Act of 1954, as amended (42 U.S.C. 2011 et seq.), and has either registered such sources with, or is operating under a license issued by a State which has an agreement in effect with the Atomic Energy Commission pursuant to section 274(b) (42 U.S.C. 2021(b)) of the Atomic Energy Act of 1954, as amended, and in accordance with the requirements of that State's laws and regulations shall be deemed to be in compliance with the radiation requirements of this part, insofar as his possession and use of such material is concerned, provided the State's program for control of these radiation sources is the subject of a currently effective determination by the Secretary of Labor that such program is compatible with the requirements of this part. Such determinations currently are in effect only in the States of Alabama, Arkansas, California, Kansas, Kentucky, Florida, Mississippi, New Hampshire, New York, North Carolina, Texas, Tennessee, Oregon, Idaho, Arizona, Colorado, Louisiana, Nebraska, and Washington.

§ 50–204.35 Application for variations from radiation levels.

(a) In accordance with policy expressed in the Federal Radiation Council's memorandum concerning radiation protection guidance for Federal agencies (25 F.R. 4402), the Director, Bureau of Labor Standards may from time to time grant permission to employers to vary from the limitations contained in §§ 50–204.21 and 50–204.22 when the extent of variation is clearly specified and it is demonstrated to his satisfaction that (1) such variation is necessary to obtain a beneficial use of radiation or atomic energy, (2) such benefit is of sufficient value to warrant the variation, (3) employees will not be exposed to an undue hazard, and (4) appropriate actions will be taken to protect the health and safety of such employees.

(b) Applications for such variations should be filed with the Director, Bureau of Labor Standards, U.S. Department of Labor, Washington, D.C. 20210.

§ 50–204.36 Radiation standards for mining.

(a) For the purpose of this section, a "working level" is defined as any combination of radon daughters in 1 liter of air which will result in the ultimate emission of 1.3×10^5 million electron volts of potential alpha energy. The numerical value of the "working level" is derived from the alpha energy released by the total decay of short-lived radon daughter products in equilibrium with 100 pico-curies of radon 222 per liter of air. A working level month is defined as the exposure received by a worker breathing air at one working level concentration for 4⅓ weeks of 40 hours each.

(b) (1) Occupational exposure to radon daughters in mines shall be controlled so that no individual will receive an exposure of more than 2 working level months in any consecutive 3-month period and no more than 4 working level months in any consecutive 12-month period. Actual exposures shall be kept as far below these values as practicable.

(2) In enforcing this section, the Director of the Bureau of Labor Standards may at any stage approve variations in individual cases from the limitation set forth in subparagraph (1) of this paragraph to comply with the requirements of the Act upon a showing to the satisfaction of the Director by an employer having a mine with conditions resulting in an exposure of more than 4 working level months but not more than 12 working level months in any 12 consecutive months that (i) under the particular facts and circumstances involved the working conditions of the employees so exposed are such that their health and safety are protected, and (ii) the employer has a bona fide plan to reduce the levels of exposure to those specified in subparagraph (1) of this paragraph as soon as practicable, but in no event later than January 1, 1971.

(c) For uranium mines, records of environmental concentrations in the occupied parts of the mine, and of the time spent in each area by each person involved in underground work shall be established and maintained. These records shall be in sufficient detail to permit calculations of the exposures, in units of working level months, of the individuals and shall be available for inspection by the Secretary of Labor or his authorized agents.

(3) For other than uranium mines and for surface workers in all mines, subparagraph (1) of this paragraph will be applicable: *Provided, however,* That if no environmental sample shows a concentration greater than 0.33 working level in any occupied part of the mine, the maintenance of individual occupancy records and the calculation of individual exposures will not be required.

(d) (1) At the request of an employee (or former employee) a report of the employee's exposure to radiation as shown in records maintained by the employer pursuant to paragraph (c) of this section, shall be furnished to him. The report shall be in writing and contain the following statement:

> This report is furnished to you under the provisions of the U.S. Department of Labor, Radiation Safety and Health Standards (41 CFR 50–204.36). You should preserve this report for future reference.

(2) The former employee's request should include appropriate identifying data, such as social security number and dates and locations of employment.

Subpart D—Gases, Vapors, Fumes, Dusts, and Mists

§ 50–204.50 Gases, vapors, fumes, dusts, and mists.

(a) No employee shall be exposed by inhalation, ingestion, skin absorption or contact to any material or substance at a concentration above that specified in the "Threshold Limit Values of Airborne Contaminants for 1968" of the American Conference of Governmental Industrial Hygienists except for the following standards—the values listed in Table I of this section which are the subject of current USASI standards and except for the values of Mineral Dusts—Table II of this section as they appear herein.

(b) In all cases, feasible engineering controls must first be determined and implemented. Methods of control in the working environment include local exhaust ventilation, general room air ventilation for dilution of the contaminant, substitution of less toxic material, and isolation or enclosure of the process or operation. In cases where protective equipment or protective equipment in addition to other measures is used as the method of protecting the employee, such protection must be approved for each specific case by a competent industrial hygienist.

TABLE I

	8-hr. time weighted average
Hydrogen Sulfide (Z37.2–1966)	20ppm
Toluene (Z37.12–1967)	200ppm
Formaldehyde (Z37.16–1967)	3ppm
Carbon Tetrachloride (Z37.17–1967)	10ppm
Trichloroethylene (Z37.19–1967)	100ppm
Tetrachloroethylene (Z37.22–1967)	100ppm
Hydrogen Fluoride (Z37.28–1969)	3ppm
Fluoride Dust as F (Z37.28–1969)	2.5mg/m³

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TABLE H

MINERAL DUSTS

Substance	Type	Limit
Silica:		
Crystalline—		
Quartz (Respirable).....	[illegible]	[illegible]
		%SiO2+2
Quartz (Total Dust).....	[illegible]	[illegible]
		%SiO2+2
Cristobalite: Use ½ the value calculated from the count or mass formulas for quartz.		
Tridymite: Use ½ the value calculated from the formulas for quartz.		
Amorphous, including natural diatomaceous earth.....	20	[illegible]
		%SiO2
Tremolite.....	5	[illegible]
		%SiO2
Silicates (less than 1% crystalline silica):		
Asbestos—12 fibers per milliliter greater than 5 microns in length [1].....	5	2
Mica.....	20	
Soapstone.....	20	
Talc.....	20	
Portland Cement.....	50	
Graphite (natural).....	15	
Coal Dust (Respirable fraction less than 5% SiO2).....		[illegible] or [illegible]
		%SiO2+2
Inert or Nuisance Dust:		
Respirable Fraction.....	15	[illegible]
Total Dust.....	50	[illegible]

NOTE: Conversion factors

mppcf/35.3 = million particles per cubic meter
= particles per c.c.

[1] Millions of particles per cubic foot of air, based on impinger samples counted by light-field techniques.

[2] The percentage of crystalline silica in the formula is the amount determined from air-borne samples, except in those instances in which other methods have been shown to be applicable.

[3] As determined by the membrane filter method at 430 X phase contrast magnification.

[4] As counted by the standard impinger, light-field count technique.

[5] Both concentration and percent quartz for the application of this limit are to be determined from the fraction passing a size-selector with the following characteristic:

Aerodynamic diameter (unit density sphere)	% passing selector
2	90
2.5	75
3.5	50
5.0	25
10	0
	0

§ 50–204.65 Inspection of compressed gas cylinders.

Each contractor shall determine that compressed gas cylinders under his control are in a safe condition to the extent that this can be determined by visual inspection. Visual and other inspections shall be conducted as prescribed in the Hazardous Materials Regulations of the Department of Transportation (49 CFR Parts 171–179 and 14 CFR Part 103). Where those regulations are not applicable, visual and other inspections shall be conducted in accordance with Compressed Gas Association Pamphlets C–6–1963 and C–8–1962.

§ 50–204.66 Acetylene.

(a) The in-plant transfer, handling, storage, and utilization of acetylene in cylinders shall be in accordance with Compressed Gas Association Pamphlet G–1–1966.

(b) The piped systems for the in-plant transfer and distribution of acetylene shall be designed, installed, maintained, and operated in accordance with Compressed Gas Association Pamphlet G–1.2–1959.

(c) Plants for the generation of acetylene and the charging (filling) of acetylene cylinders shall be designed, constructed, and tested in accordance with the standards prescribed in Compressed Gas Association Pamphlet G–1.4–1966.

§ 50–204.67 Oxygen.

The in-plant transfer, handling, storage, and utilization of oxygen as a liquid or a compressed gas shall be in accordance with Compressed Gas Association Pamphlet G–4–1962.

§ 50–204.68 Hydrogen.

The in-plant transfer, handling, storage, and utilization of hydrogen shall be in accordance with Compressed Gas Association Pamphlets G–5.1–1961 and G–5.2–1966.

§ 50–204.69 Nitrous oxide.

The piped systems for the in-plant transfer and distribution of nitrous oxide shall be designed, installed, maintained, and operated in accordance with Compressed Gas Association Pamphlet G–8.1–1964.

§ 50–204.70 Compressed gases.

The in-plant handling, storage, and utilization of all compressed gases in cylinders, portable tanks, rail tankcars, or motor vehicle cargo tanks shall be in accordance with Compressed Gas Association Pamphlet P–1–1965. Compressed gas cylinders, portable tanks, and cargo tanks shall have pressure relief devices which shall be installed and maintained in accordance with Compressed Gas Association Pamphlets S–1.1–1963 (with 1965 addenda) and S–1.2–1963.

§ 50–204.71 Safety relief devices for compressed gas containers.

Compressed gas cylinders, portable tanks, and cargo tanks shall have pressure relief devices installed and maintained in accordance with Compressed Gas Association Pamphlets S–1.1–1963 and 1965 addenda and S–1.2–1963.

§ 50–204.72 Safe practices for welding and cutting on containers which have held combustibles.

Welding or cutting or both on containers which have held flammable or combustible solids, liquids, or gases, or have contained substances which may produce flammable vapors or gases will not be attempted until the containers have been thoroughly cleaned in strict accordance with the rules and procedures embodied in American Welding Society Pamphlet A–6.0–65, edition of 1965.

Subpart E—Transportation Safety

§ 50–204.75 Transportation safety.

Transportation in connection with public contracts, as listed in § 50–204.3(a)(3) shall be conducted in accordance with the U.S. Department of Transportation requirements. Where such requirements do not apply, Chapters 10, 11, 12, and 14 of the Uniform Vehicle Code of the National Committee on Uniform Traffic Laws and Ordinances, 1962 Edition, shall be used.

Subpart F—Variations

§ 50–204.80 Variations.

(a) Upon the written request of any interested person, the Director of the Bureau of Labor Standards may in particular cases apply variations from the provisions of this part in enforcing the Walsh-Healey Public Contracts Act following consideration of the particular facts and circumstances involved whenever he is satisfied that the safety and health of employees is equally protected by such variations.

(b) The provisions of this section shall not apply to §§ 50–204.35 and 50–204.36, which contain separate and specific variations procedures.

2. Section 50–201.502 is revised to read as follows:

§ 50–201.502 Record of injuries.

(a) Every person who is or shall become a party to a Government contract which is subject to the provisions of the Walsh-Healey Public Contracts Act and the regulations thereunder, or who is performing or shall perform any part of such contract subject to the provisions of such act or regulations, shall maintain the records specified below which shall be available for inspection by authorized representatives of the Secretary of Labor:

(1) Records of all injuries to employees, including a brief description of the manner of occurrence and the date and duration of disability.

(2) Records of injury frequency rates, calculated annually on a calendar year basis commencing the first of January of each year, as defined in United States of America Standards Institute, Z16.1–1967 "Method of Recording and Measuring Work Injury Experience."

(3) Records of injury severity rates, calculated annually on a calendar year basis commencing the first of January of each year, as defined in United States of America Standards Institute, Z16.1–1967 "Method of Recording and Measuring Work Injury Experience."

(b) The records required in paragraph (a) of this section shall be kept on file at least 3 years from the date of entry.

(c) Where records are kept on a fiscal or insurance year basis, they shall be accepted as being in compliance with subparagraphs (2) and (3) of paragraph (a) of this section.

(Sec. 4, 49 Stat. 2036; 41 U.S.C. 2039)

Signed at Washington, D.C. this 10th day of January 1969.

WILLARD WIRTZ,
Secretary of Labor.

[F.R. Doc. 69–563; Filed, Jan. 16, 1969; 8:45 a.m.]

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THE DISCOVERY COMPANY

Calidria ASBESTOS

ASBESTOS TOXICOLOGY REPORT

It has been known for years that some persons working in asbestos production were prone to develop a disabling lung disease. In time, this condition became known as asbestosis and was related to exposure to high concentrations of asbestos dust. With further experience, it was found that men could work with asbestos without development of lung disease if dust concentrations were kept below a certain level.

It has been generally accepted that a worker will not develop asbestosis if he is exposed to no more than 5 million particles per cubic foot of air, even if this exposure continues for his entire working lifetime. Although no cases of asbestosis are known to have occurred when exposures have been maintained at or below this level, the ACGIH (which sets the threshold limit value (TLV) in the U. S. A.) has indicated they intend to lower the TLV for asbestos to 2 million particles per cubic foot in an effort to increase the safety factor incorporated in the limit. The U. S. Department of Labor has already issued a regulation under the Walsh-Healy Act placing the TLV for asbestos at 2 million particles per cubic foot for public contracts in which they have jurisdiction. This concentration of dust is generally not visible in the average work area unless a beam of light causing a Tyndall effect is present. Usually the dust concentration must be from 8-10 million particles per cubic foot (MPPCF) before its presence is visible in average lighting conditions.

Several years ago, it was reported that there was an increase in the incidence of cancerous tumors, especially of the lung, associated with asbestosis. Recently there have been reports of some cancers occurring in individuals exposed to asbestos dust, but who have not developed clinical asbestosis. It is believed by most authorities that these cases have been associated with exposures significantly exceeding the Threshold Limit Value.

A type of cancer named mesothelioma has been noted to be associated with asbestos exposure in recent years. These tumors, while rather few in number to date, may occur in individuals with histories of only slight exposures, and that as much as twenty to forty years earlier. There is considerable evidence that crocidolite is most frequently associated with mesotheliomas. From the data available it appears that the TLV of 5 MPPCF may not be low enough to protect against mesothelioma. Research on the problem continues.

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Control of asbestos dust exposure is therefore necessary. The control methods are the standard ones applicable to a variety of dusty operations. They include closed flow systems, wet processes where possible, and adequate exhaust ventilation where openings in the system are necessary. Pelletizing is sometimes used to improve the handling characteristics of otherwise dusty materials. Where satisfactory containment to stay within the Threshold Limit Value is impractical or impossible, efficient and reliable respirators are available for the protection of the employee. A program of environmental monitoring is highly desirable to determine that Threshold Limit Values are not being exceeded. In manufacturing industries it would be desirable to know the dust concentrations where the asbestos is dumped from bags into the process. Concentrations should also be determined where dusting occurs in finishing products. While initial dust determinations should be made at frequent intervals, once the level has been established as satisfactory, the frequency may be extended to occasional tests to assure continuation of a satisfactory condition.

Pre-employment and periodic physical examination of workers are desirable. These should include chest X-rays to insure that the worker has no chest condition prior to work with asbestos and to determine that no lung changes are resulting from work with asbestos.

It is believed that the addition of asbestos at the proposed levels during the manufacture of products would be harmless to the consumer. Total dusting would have to be well in excess of any levels acceptable to the consumer for the asbestos concentrations to approach the Threshold Limit Value.

In conclusion, while asbestos dust in excess of the Threshold Limit Value is potentially harmful, as are many other dusts encountered in industry, it is as readily controlled as other such dusts and it can be used safely with appropriate precautions.

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THE DISCOVERY COMPANY

ASBESTOS

NEWS RELEASE

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FOR RELEASE: Upon Receipt

NEWLY DEVELOPED ASBESTOS PELLETS CUT SHIPPING COSTS 44%

By pelletizing its line of high purity Calidria asbestos products, Union Carbide Corporation has made product handling easier, and shipping and storage costs substantially lower than could be attained with other asbestos forms.

Asbestos pellets represent a major innovation in the industry as it marks the first time that the material is available in this form. The ability to make the new shape stems from the use of a proprietary wet process which breaks down the ore's random oriented fiber bundles and removes rock and other foreign matter, leaving essentially pure asbestos.

Although pelletized asbestos offers many advantages to the user -- ease of handling, reduced dusting, and less troublesome and costly storage -- one of the more significant benefits is lower shipping rates, particularly for overseas ocean shipments. Due to the fact that the shipping density of asbestos pellets, 49.8 ft.^{3}/ton, is considerably lower than the 107.4 ft.^{3}/ton of the open or ground grades, over twice as much asbestos pellets can be loaded or warehoused in the same volume.

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For example, a 24-foot container can accommodate 45,750 pounds of pelletized asbestos as against 22,400 pounds of the open or ground material. These are maximum contents based on weight and volume respectively. Because greater quantities of asbestos can be shipped in a given load, the savings in shipping costs are considerable, amounting to $1.20/cwt. for shipments from San Francisco to Antwerp.

Pellets now account for more than 90% of Union Carbide's export shipments of asbestos. The use of this form is also heavily used in domestic loads, totaling about 65% of all shipments.

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CAPTIONS:

Figure 1: Shows 24-foot container being loaded for Japan with bags of asbestos pellets. In this form, over twice as much asbestos can be loaded in this van size, resulting in significantly lower shipping costs.

Figure 2: Comparison between pelletized asbestos (right) and open or ground material. This marks the first time in the industry that asbestos is available in pellet form.

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