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Handbook of

ASBESTOS TEXTILES

THIRD EDITION

ASBESTOS TEXTILE INSTITUTE
FOUNDED 1944

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TO THE MEMORY OF

DR. MYRIL C. SHAW

WHO SERVED AS

EXECUTIVE SECRETARY

OF THE ASBESTOS TEXTILE INSTITUTE

FROM 1948 TO 1963

AND WHOSE WORK AS RESEARCH FELLOW

CONTRIBUTED IN COUNTLESS WAYS

TO THE ADVANCEMENT

OF THE ASBESTOS TEXTILE INDUSTRY



From the mineral asbestos, hard and rocklike in structure, come the soft, silky fibers that are made into many forms of textile products

INTRODUCTION

LEGEND tells us that the Emperor Charlemagne delighted to mystify his dinner guests by throwing an asbestos tablecloth into a roaring fire and then removing it, unharmed, from the flames.

Thus was demonstrated, more than eleven hundred years ago, one of the outstanding characteristics of textiles made from the fibers of that remarkable mineral, asbestos.

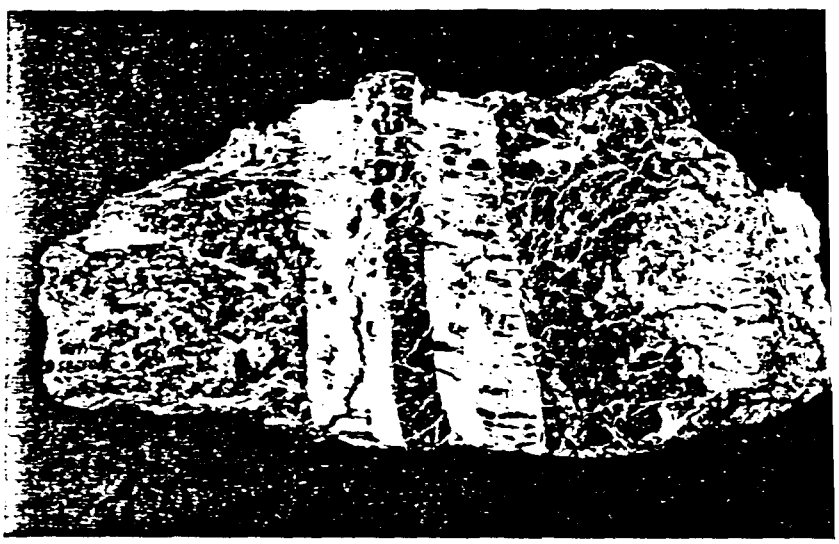
Today, the products which come from the cards, spinning frames and looms of asbestos textile manufacturers constitute a virtually indispensable part of our modern industrial economy.

In the electrical industry, for example, asbestos textiles meet the special requirements of an efficient insulation for wires and cables. As such, they are widely used in ranges, refrigerators and other home appliances, as well as in industrial furnaces, ovens, welding machines, motors and transformers. They are a basic component of mechanical packings and gaskets. They assure the stamina and heat resistance so essential in automotive and industrial friction materials, gears, bushings, bearings and other vital mechanical parts.

Impregnated with resins and ceramics, asbestos textiles increase the strength and durability of numerous products. In one of their newer applications in this form, they serve as thermal insulation in the nose cones, fins, combustion chambers and other areas of missiles and rockets where temperatures in excess of 5000° F are encountered.

Asbestos textiles are also found in such widely diversified uses as safety clothing, fire-smothering blankets, conveyor belts, filter cloths, fireproof curtains and draperies, and as thermal insulation for exhaust pipes.

In fact, there is scarcely a major industry or activity that does not benefit in some way from the use of asbestos textiles. They have raised safety standards, improved product performance, lowered costs and contributed other important advantages in numerous fields—and their range of usefulness is ever-increasing.



Serpentine rock with veins of chrysotile asbestos fibers as they appear before separation

The Mineral Asbestos

Asbestos is the name given to a group of fibrous minerals that o in different forms in many countries throughout the world. The wor derived from the ancient Greek language and its first recorded use by the Roman naturalist, Pliny the Elder, in the first century A. although asbestos itself was known to the Greeks and used by ther an even earlier date.

Early in the first century, the Greek geographer Strabo referred to a st from southern Greece that was carded and woven into handkerchi "Karystos lithos," the Greeks called it, naming it after the city wher was found. The Romans had also developed uses for this amazing stone it is known that they wove it into lamp wicks and cremation cloth wrapping their dead. And that famous Venetian traveler Marco Polo, hc from wandering in Siberia in the thirteenth century, brought news c "fossil substance" which, "when woven into cloth and thrown into the f remains incombustible." He, too, had become acquainted with asbes

These early uses were of minor significance, however, and it was not u the advent of the steam engine, with its need for insulation and pack that asbestos really began to assume commercial importance. The ni teenth century saw the discovery of large deposits in Canada and So

Africa and today asbestos is one of modern man's most important raw materials. As a component in an uncounted number of essential products, it is virtually indispensable to us in our everyday living.

MAJOR PROPERTIES

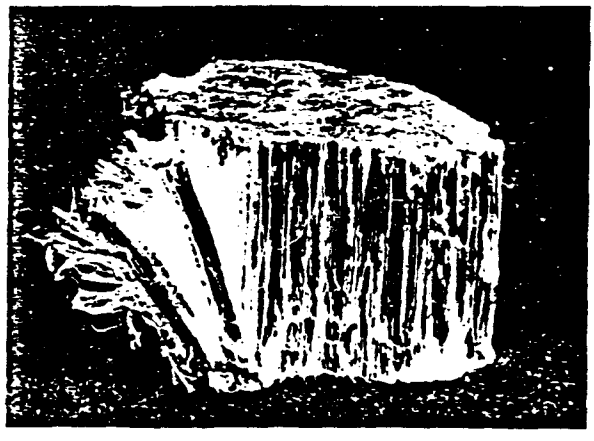
The commercial value of asbestos depends largely on two physical characteristics – its incombustibility and its unique fibrous structure. The latter permits it to be separated into filaments or fibers, many of which possess high tensile strength and unusual flexibility and are adaptable to numerous uses. Some types of asbestos can be spun into yarn and woven into cloth and are thus the basic raw materials from which asbestos textiles are made.

Other valuable properties of asbestos are its resistance to heat, moisture and corrosion. However, these properties, like some of those already mentioned, are found to vary considerably with the different types of asbestos and, to a lesser extent, between different specimens of the same mineral. Tables B and C, pages 8 and 9, provide an interesting comparison of the properties of several varieties of asbestos.

VARIETIES OF ASBESTOS

Some thirty or more minerals of fibrous crystalline structure comprise the asbestiform group but only six have economic significance. These are, in order of importance, chrysotile, crocidolite, amosite, anthophyllite, tremolite and actinolite. Chrysotile is a fibrous form of serpentine; the other five are amphiboles.

Because it is superior to other types of asbestos for textile processing, as well as for industrial purposes generally, chrysotile accounts for about 95 per cent of the total world production of natural mineral fibers.[1]



Chrysotile asbestos fibers after separation from the mother rock. The fibers have been pulled apart to disclose their fine silky nature

CHRYSOTILE

Chrysotile is a hydrated magnesium silicate having an empirical formula which, in the past, has often been expressed as $3MgO.2SiO_2.2H_2O$. However, recent studies of the structure of chrysotile show that all the water in the composition exists as hydroxyl (OH^-) ions. Thus, the empirical formula is perhaps more correctly expressed as $Mg_3[(OH)_4Si_2O_5]$ or a *multiple thereof* to show the actual state of the water in the structure.

Origin: Almost all of the world's resources of chrysotile asbestos are associated with ultrabasic igneous rocks which were injected into the earth's crust. A prerequisite to the formation of asbestos was the hydrothermal alteration or rock metamorphism of the crystalline ultrabasic rocks to amorphous serpentine. Equally important in the asbestos formation process were the structural deformations which produced wide scale fracturing within the solid serpentine mass, permitting the entry and circulation of siliceous solutions.

A number of hypotheses have been advanced to explain the actual manner of asbestos formation. The most acceptable of these is that the siliceous solutions entered the fractures within the serpentine mass under conditions of high temperature and pressure. Over a period of time magnesium silicate was dissolved from the adjacent rock. Gradually, both the temperature and pressure moderated such that the solutions became supersaturated with magnesium silicate and crystallization took place in the form of fibrous asbestos. The asbestos fibers grew in a direction normal to the fracture and the iron released during the process was deposited as magnetite.

Nature has exercised some variety in the formation of chrysotile, as is apparent by the fact that "impurities" in the crystal structure are the rule, not the exception. An example is the presence of atoms of iron replacing magnesium in the crystal lattice. Such replacement is quite variable. Other elements are also present. These include traces of calcium, aluminum and other elements in amounts so small that they are disclosed only by spectrographic analyses. Magnetite and, to a lesser extent, chromite are found frequently lying between the serpentine and the vein of chrysotile and consequently small pieces may be found in fiberized chrysotile. But despite these variations, chrysotile is generally more uniform in quality than other types of asbestos.

Properties: The properties of chrysotile fibers which particularly adapt them to the manufacture of asbestos textiles are length, strength, toughness, flexibility or pliability and a minimum of magnetic or conductive

[1] Asbestos – A Materials Survey, U. S. Dept. of the Interior, Bureau of Mines, 1959.

particles. Chrysotile fibers are the most flexible of any asbestos fibers. Their tensile strength is high, and individual values of more than 800,000 psi have been recorded. However, the measured tensile strengths of a series of fiber bundles tend to show variations as a function of length. Although rare specimens of chrysotile have been found up to several inches in length, commercial fiber ranges downward from three-quarters of an inch. In general, only the longest available fibers are used in the processing of textiles. See "Textile Grades," page 20.

Resistance to Heat: Chrysotile rates high among the asbestos minerals in resistance to destruction by heat. Under continuous and long exposures, there is loss of a small part of the structural water in the fiber at 750° F and at 1110° F most of the structural water is lost. Fusion occurs at 2770° F. However, under transient conditions and those short of equilibrium, chrysotile will retain its structure over a much higher temperature range. Practical examples of this are found in numerous high temperature applications where the fibers, in combination with other materials, successfully withstand exposure to temperatures as high as 6000° F.

Recent studies of chrysotile asbestos by means of the electron microscope and gas adsorption and desorption isotherms show that the fibers are tubular in structure but with the fiber pores generally filled or blocked with an amorphous material of the same chemical composition. The structure of the fiber consists of layers of silica and magnesium hydroxide with the hydroxyl on the exterior surface. This accounts for the unique hydrous characteristics exhibited by chrysotile.

Spinnability: The better grades of chrysotile are noted for their extreme fineness or silkiness which, together with their exceptional flexibility and high tensile strength, results in superior spinnability. Chrysotile may be subdivided into ultimate fibrils so fine that they are revealed only with an electron microscope. The diameters of these minute fibrils appear to be in the range of 200Å to 400Å (1Å=0.0000000039 in.). This is many times smaller than the diameters of other commercial fibers. See Table G, page 11.

The crude chrysotile from different localities is, however, variable in yielding to the fiberizing process, the types which are easily fiberized being in general the finest, strongest and silkiest fibers.

Fibers from different sources have distinctive, characteristic "working" properties. Chrysotile may be soft and unctuous to the touch, or it may be somewhat harsh. Harshness, which generally is accompanied by a lack of optimum pliability, resists fiberizing and requires more time in processing.

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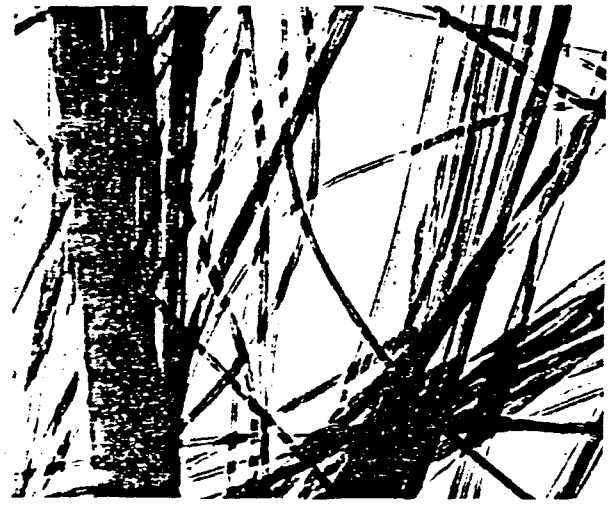

Chrysotile asbestos fibers as seen under an electron microscope at approximately 40,000 magnifications. Their tubular structure is apparent from the light lines running down the center of most of the individual fibers

When harshness is accompanied by brittleness the fiber may be unsuitable for textile processing. These objectionable properties may be found in chrysotile derived from both igneous and sedimentary formations—in massive serpentine or in tabular bodies of serpentinized dolomite. They are not peculiar to either. But in the chrysotile of Arizona there are degrees of harshness, including "semi-harsh." Semi-harsh chrysotile requires a special technique to make it suitable for textile use.

The knowledge of these things that may impair the quality of chrysotile is a part of the know-how gained through experience and possessed by the personnel of the producing organizations in the asbestos textile industry.

Sources: Chrysotile, most important of the natural mineral fibers, is fortunately also the most abundant of those having commercial value. It occurs in many countries but Canadian and African deposits are the major sources of the fiber that support the American asbestos textile industry.

In Canada, Quebec has long been the principal source of chrysotile, although extensive deposits are also mined in Newfoundland and British Columbia. Canadian output amounted to 1,416,650 short tons in 1964[2], a major portion of the total free world production of asbestos fiber. In its crude rock form, Canadian chrysotile usually has a dark green luster, but the fibers appear white when fully opened. For this reason, it is known in the trade as "white asbestos." The British Columbia chrysotile, valued for its low magnetic iron content, is particularly well adapted for use as electrical insulation.

[2] U. S. Dept. of the Interior, Bureau of Mines Minerals Yearbook, 1964.

Other important suppliers of chrysotile fiber include Rhodesia, which produced approximately 153,000 short tons in 1964[3], and the United States, with a production of 101,092[3] short tons during the same year. The "soft" iron-free variety of Arizona fiber is particularly suitable for electrical insulation but little has been available in recent years.

Chrysotile is also produced in substantial tonnages in Italy, Swaziland and the Union of South Africa and in smaller amounts in Cyprus, Japan, Yugoslavia and other countries. Among Communist countries Russia is the leading producer, with an estimated production of 1,300,000 short tons in 1964.[3]

OTHER TYPES OF ASBESTOS

Crocidolite: An amphibole of the hornblende group, crocidolite is the blue asbestos of commerce. It is a complex silicate of iron, magnesium and sodium corresponding approximately to the chemical formula $Na_2MgFe_3[(OH)Si_4O_{11}]_2$. Its composition, like that of chrysotile is found to vary.

Crocidolite is more difficult to process into a spinnable fiber than chrysotile, although some yarns and other textile products are made of this fiber. Crocidolite is also used in the form of mat, roving or as dispersed fiber as a reinforcement for plastics, particularly where high chemical resistance is required. Its resistance to heat is lower than that of chrysotile but its tensile strength is generally very high, a maximum of 876,000 psi having been recorded. The most important advantage of crocidolite is its superior resistance to attack by acids.

The major sources of crocidolite are the Cape and Transvaal Provinces of South Africa, which produced nearly 103,000 short tons in 1964[3]. Deposits also exist in Australia and Bolivia. Because of its low strength, the soft silky Bolivian crocidolite falls just short of being a textile fiber. It has good dielectric properties and is suitable for felting.

Amosite: Also a fibrous amphibole, amosite – $MgFe_6[(OH)Si_4O_{11}]_2$ – is essentially a ferrous silicate in which a proportion of the iron is replaced by magnesium. The ratio of magnesium to iron may vary and minor replacement of the main components by other elements may also occur.

Amosite possesses good tensile strength and is more resistant to heat than chrysotile or crocidolite. Its fibers are flexible and unusually long and although not well adapted to spinning because of their relative harshness, they are well suited for the production of non-woven textile fabrics for

[3] U. S. Dept. of the Interior, Bureau of Mines Minerals Yearbook, 1964.

reinforcement of plastics and of bonded and unbonded felts and batts for fire protection applications. Long fiber amosite is used principally in the manufacture of thermal insulation.

Deposits located in Transvaal Province, Union of South Africa, provide the only commercial source of amosite fiber. Approximately 77,000 short tons were produced there in 1964[3].

Anthophyllite: Essentially a silicate of magnesium and iron, usually with a small amount of aluminum, anthophyllite belongs to the group of orthorhombic amphiboles. Its chemical formula may be expressed as $(Mg,Fe)_7[(OH)Si_4O_{11}]_2$. The fibers of anthophyllite are usually brittle and lacking in tensile strength and are therefore not suitable for textiles.

Tremolite and Actinolite: These monoclinic amphiboles are least important of the commercially used varieties of asbestos.

Tremolite – $Ca_2Mg_5[(OH)Si_4O_{11}]_2$ – is a calcium-magnesium silicate whose fibers are often long and silky but generally too brittle and of inadequate tensile strength for use in the fabrication of textiles. It is of value principally for filtration purposes because of its freedom from iron and its resistance to attack by acids. Most of the tremolite fiber produced comes from deposits located in northern Italy.

Actinolite – $Ca_2(Mg,Fe)_5[(OH)Si_4O_{11}]_2$ – is similar in composition to tremolite except for the presence of iron which replaces some of the magnesium. The fibers are too weak and brittle for spinning but have good resistance to acids. Its practical value is limited and production is small.

TABLE A—CHEMICAL COMPOSITION OF VARIOUS TYPES OF ASBESTOS*

	Chrysotile	Crocidolite	Amosite	Anthophyllite	Tremolite
SiO_2	37-44%	49-53%	49-53%	56-58%	51-62%
MgO	39-44%	0-3%	1-7%	28-34%	0-30%
FeO	0.0-6.0%	13-20%	34-44%	3-12%	1.5-5.0%
Fe_2O_3	0.1-5.0%	17-20%	———	———	———
Al_2O_3	0.2-1.5%	———	2-9%	0.5-1.5%	1.0-4.0%
H_2O	12.0-15.0%	2.5-4.5%	2-5%	1.0-6.0%	0-5.0%
CaO	Tr.-5.0%	———	———	———	0-18%
Na_2O	———	4.0-8.5%	———	———	0-9%
$CaO+Na_2O$.	———	———	0.5-2.5%	———	———

*Encyclopedia of Chemical Technology, Vol. 2—Anthrone to Carbon Copyright 1948. Interscience Publisher, New York and London.

TABLE B—PHYSICAL PROPERTIES OF ASBESTOS FIBERS*

	Chrysotile	Crocidolite	Amosite	Anthophyllite	Tremolite	Actinolite
Color	Green, gray, amber to white	Blue	Gray, yellow to dk. brown	Yellowish brown, grayish white	Gray-white, greenish,yellowish, bluish	Greenish
Texture	Soft to harsh, also silky	Soft to harsh	Coarse but somewhat pliable	Harsh	Generally harsh, sometimes soft	Harsh
Flexibility	High	Good	Good	Poor	Poor	Poor
Spinnability	Very good	Fair	Fair	Poor	Poor	Poor
Resistance to Destruction by Heat	Good. Brittle at high. temp.	Poor, fuses	Good. Brittle at high temp.	Very good	Fair to good	———
Tensile Strength, psi	824,000 max.†	876,000 max.†	287,000 max.†	1,000 and less	1,000 to 8,000	1,000 and less
Fusion Point, °F	2770	2180	2550	2675	2400	2540
Specific Heat, Btu/lb/°F	0.266	0.201	0.193	0.210	0.212	0.217
Electric Charge	Pos.	Neg.	Neg.	Neg.	Neg.	Neg.
Filtration Properties	Slow	Fast	Fast	Medium	Medium	Medium

*Canadian Mining and Metallurgical Bulletin, April, 1951 †R. Zukowski and R. Gaze, Nature, 183, 35 (1959)

[illegible] Properties	Slow	Fast	[illegible]	[illegible]	[illegible]	[illegible]

*Canadian Mining and Metallurgical Bulletin, April, 1951 †R. Zukowski and R. Gaze, Nature, 183, 35 (1959)

TABLE C—CHEMICAL AND MINERALOGICAL PROPERTIES OF ASBESTOS FIBERS*

	Chrysotile	Crocidolite	Amosite	Anthophyllite	Tremolite	Actinolite
Essential Composition ..	Hydrous silicate of magnesia	Silicate of Na and Fe with some water	Silicate of Fe and Mg, higher iron than anthophyllite	Mg silicate with iron	Ca and Mg silicate with some water	Ca Mg Fe silicate; water up to 5%
Crystal Structure	Fibrous and asbestiform	Fibrous	Prismatic, lamellar to fibrous	Prismatic, lamellar to fibrous	Long and thin columnar to fibrous	Long and thin columnar to fibrous
Crystal System	Monoclinic and orthorhombic†	Monoclinic	Monoclinic†	Orthorhombic	Monoclinic	Monoclinic
Mineralogical Structure.	In veins of serpentine, etc.	Fibrous in iron stones	Lamellar, coarse to fine fibrous and asbestiform	Lamellar, fibrous asbestiform	Long, prismatic and fibrous aggregates	Reticulated long prismatic crystals and fibers
Mineral Association ...	In altered peridotite adjacent to serpentine and limestone near contact with basic igneous rocks	Iron rich silicious argillite in quartzose schists	In crystalline schists, etc.	In crystalline schists and gneisses	In Mg limestones as alteration prod of magnesian rocks, metamorphic and igneous rocks	In limestone and in crystalline schists
Veining	Cross and slip fibers	Cross fiber	Cross fiber	Slip, mass fiber unoriented and interlacing	Slip or mass fiber	Slip or mass fiber
Luster	Silky	Silky to dull	Vitreous, somewhat pearly	Vitreous to pearly	Silky	Silky
Hardness	2.5-4.0	4	5.5-6.0	5.5-6.0	5.5	6±
pH	9.2 to 9.8	——	- - -	Neutral		-
Specific Gravity	2.4-2.6	3.2-3.3	3.1-3.25	2.85-3.1	2.9-3.2	3.0-3.2
Cleavage	010 perfect	110 perfect	110 perfect	110 perfect	110 perfect	110 perfect
Optical Properties	Biaxial positive, extinction parallel	Biaxial ± extinction inclined	Biaxial positive, extinction parallel	Biaxial positive, extinction parallel	Biaxial negative, extinction inclined	Biaxial negative, extinction inclined
Refractive Index	1.50-1.55	1.7 pleochroic	1.64±	1.61±	1.61±	1.63± weakly pleochroic

*Canadian Mining and Metallurgical Bulletin, April, 1951 †As recently determined

TABLE D—EFFECT OF TEMPERATURE ON LOSS IN WEIGHT OF ASBESTOS FIBERS*

Temp. F	Time	Loss In Weight (Per Cent)				
		Amosite	Anthophyllite	Chrysotile	Crocidolite	Tremolite
400	2 hrs.	0.23	0.05	0.30	0.08	0.04
600	"	0.57	0.24	0.85	0.25	0.08
700	"	0.80	0.30	1.78	0.49	0.13
800	"	0.98	0.38	2.17	0.73	0.22
900	"	1.07	0.41	2.83	0.83	0.26
1000	"	1.16	0.44	3.99	0.86	0.29
1100	"	1.36	0.52	10.38	1.00	0.37
1200	"	1.39	0.54	12.75	1.04	0.37
1400	"	1.43	0.54	13.43	1.03	0.47

*Canadian Mining and Metallurgical Bulletin, April, 1951

TABLE E—COMPARISON OF SURFACE AREA OF VARIOUS FIBERS WITH ASBESTOS*

Type of Fiber	Surface Area by N_2 Adsorption (Sq. Cm./Gram)
Nylon	3,100
Acetate Rayon	3,800
Cotton	7,200
Silk	7,600
Wool	9,600
Viscose Rayon	9,800
Asbestos (Chrysotile)	130,000 to 220,000†

*Canadian Mining and Metallurgical Bulletin, April, 1951

†Recent studies show that the maximum surface area may run as high as 500,000 sq. cm./gram

TABLE F—COMPARISON OF TENSILE STRENGTHS OF VARIOUS FIBERS*

Type of Fiber	Tensile Strength (psi) Maximum
Acetate Rayon	23,000 to 30,000†
Nylon	80,000 to 117,000†
Glass	315,000
Orlon	80,000
Cotton	125,000
Silk	83,000
Wool	28,000
Asbestos (Chrysotile)	824,000‡

*Tests conducted by Harris Research Laboratories, Washington, D. C., except where noted

†Depending on type

‡R. Zukowski and R. Gaze, Nature, 183, 35 (1959)

EIGHT

EMOLITE

0.04
0.08
0.13
0.22
0.26
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0.37
0.37
0.47

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TABLE G—COMPARISON OF DIAMETERS OF VARIOUS FIBERS WITH ASBESTOS*

Type of Fiber	Fiber Diameter (Inches)	Fibrils in One Linear Inch
Human Hair	0.00158	630
Cattle	0.000985	1,015
Wool	0.0008 to 0.0011	910 to 1,250
Cotton	0.0004	2,500
Rayon	0.0003	3,300
Nylon	0.0003	3,300
Glass	0.00026	3,840
Rock Wool	0.000142 to 0.000284	3,520 to 7,040
Asbestos (Chrysotile)	0.000000706 to 0.00000118	850,000 to 1,400,000

Canadian Mining and Metallurgical Bulletin, April, 1951

TABLE H—EFFECT OF HEAT ON TENSILE STRENGTH OF CANADIAN CHRYSOTILE CRUDE*

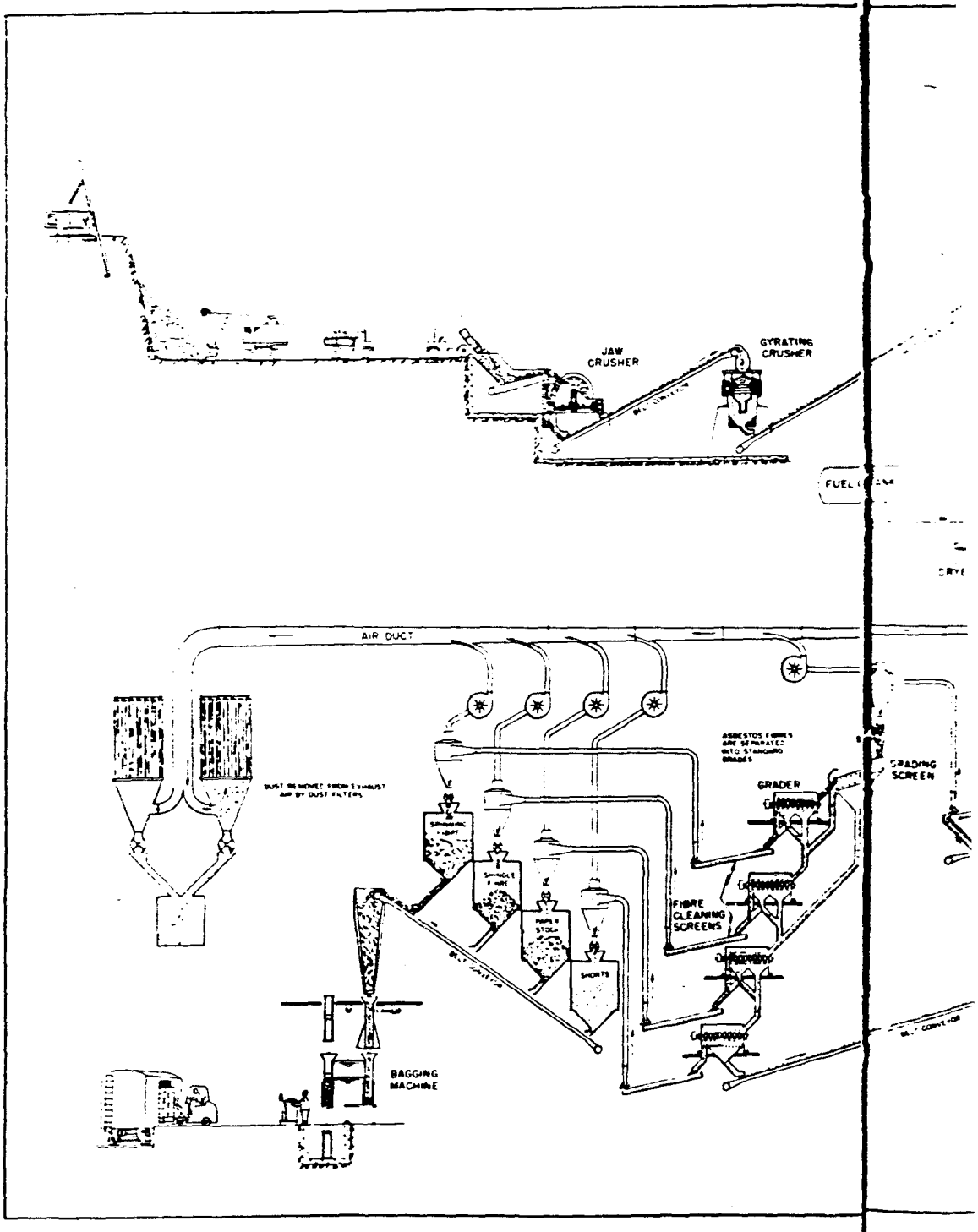
	Tensile Strength (psi)	Per Cent of Original Tensile Strength
Original Crude—No Heat	131,000	——
Heated 3 minutes at 600 F	120,000	91.6
Heated 3 minutes at 800 F	96,000	73.3
Heated 3 minutes at 1000 F	78,000	59.5
Heated 3 minutes at 1200 F	42,000	32.0

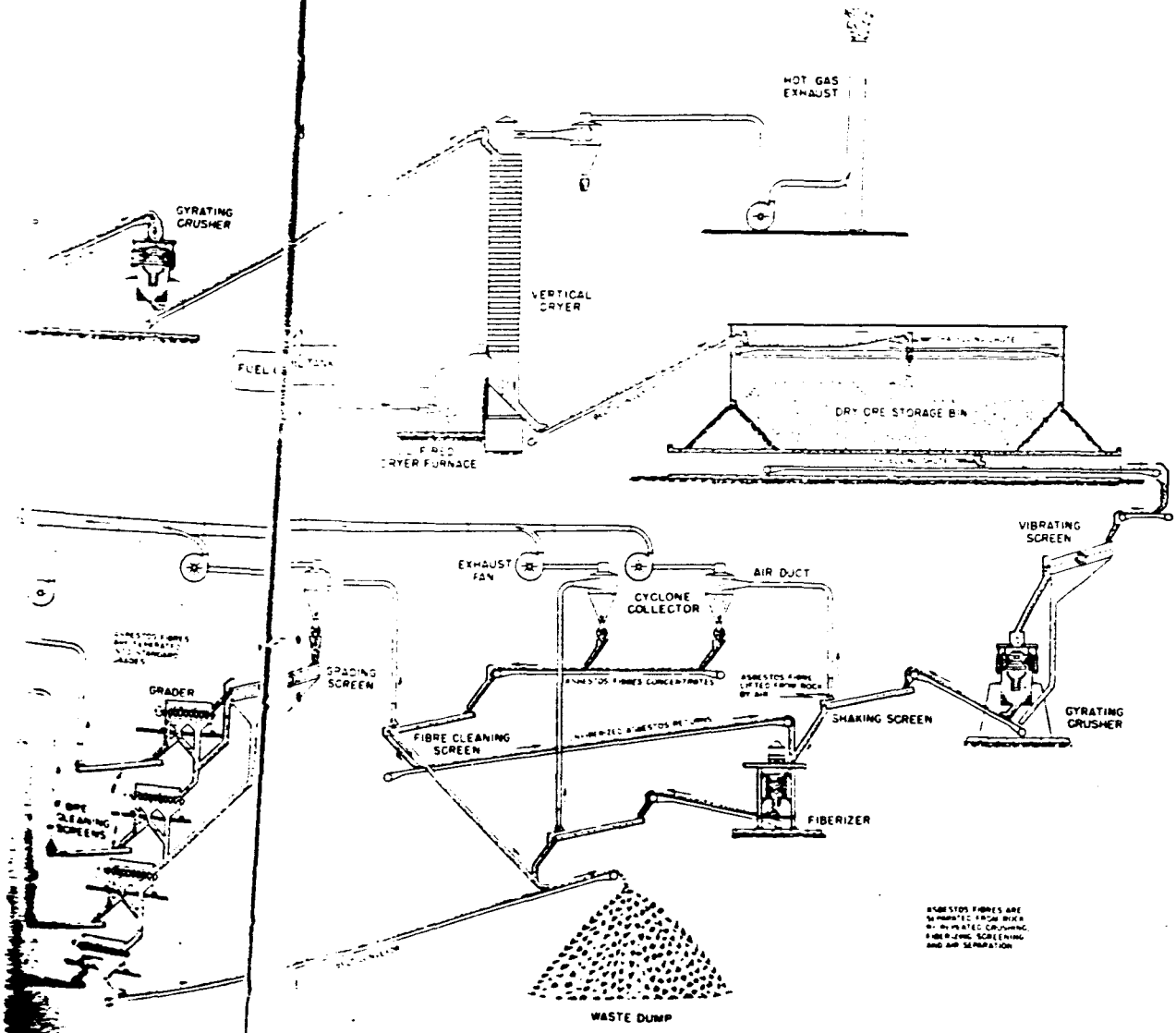
Canadian Mining and Metallurgical Bulletin, April, 1951

TABLE J—COMBUSTION ANALYSIS OF CHRYSOTILE ASBESTOS*

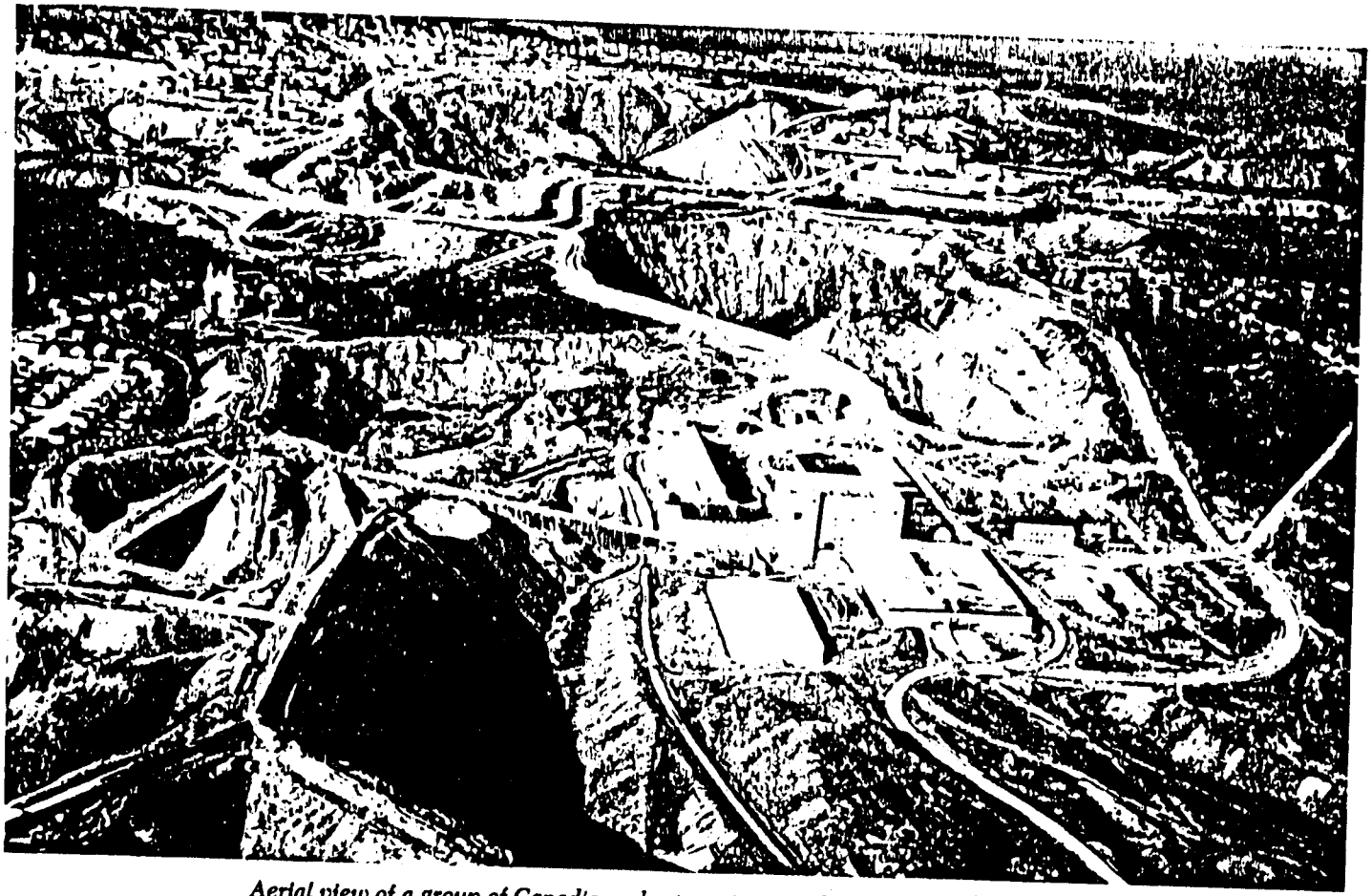
Source of Fiber	Temp. F	Per Cent H_2O	Per Cent CO_2	Total Per Cent H_2O+CO_2	Per Cent Ignition Loss of Fiber	CO_2 Calculated in Terms of Percentage of $MgCO_3$	$CaCO_3$
Arizona	1000	3.37	0.54	3.91	3.87	1.03	——
	1800	12.89	1.91	14.80	14.80	1.03	3.11
Australian	1000	1.50	0.66	2.16	2.06	1.26	——
	1800	12.48	0.96	13.44	13.33	1.26	0.68
Canadian (A)	1000	5.47	0.85	6.32	6.23	1.62	——
	1800	14.28	0.97	15.25	15.17	1.62	0.27
Rhodesian	1000	1.82	2.54	4.36	4.28	4.85	——
	1800	12.00	2.89	14.89	14.84	4.85	0.79
Canadian (B)	1000	3.75	0.45	4.20	4.14	0.86	——
	1800	13.31	0.48	13.79	13.75	0.86	0.07
Russian	1000	1.98	0.77	2.75	2.64	1.47	——
	1800	11.74	1.06	12.80	12.72	1.47	0.66
Canadian (C)	1000	2.25	0.47	2.72	2.66	0.90	——
	1800	11.93	0.51	12.44	12.40	0.90	0.09

*Canadian Mining and Metallurgical Bulletin, April, 1951


JAW CRUSHER
GYRATING CRUSHER
AIR DUCT
GRADER
FIBRE CLEANING SCREENS
BAGGING MACHINE



Flowsheet of a typical asbestos mine and mill



Aerial view of a group of Canadian asbestos mines at Thetford Mines, Quebec

... of a group of Canadian asbestos mines at Thetford Mines, Quebec

The Mining, Milling and Grading of Asbestos Fibers

In the recovery of Canadian chrysotile, from which most of the asbestos textile products made in the United States are processed, both open pit and underground mining methods are used.

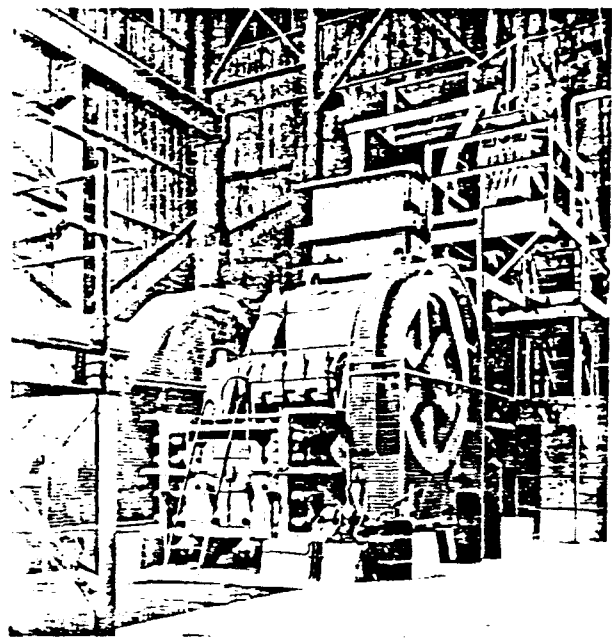
Open pit mining is essentially a quarrying operation. Holes are first drilled in the face of the deposit with compressed air drills and the fiber-bearing rock is then loosened by blasting. After a rough separation of ore and barren rock in the pit, the ore is loaded into trucks by power shovels and transported to the mill.

Underground mining methods are similar to those employed in the removal of coal and other minerals. In one method, known as block caving, large blocks of ore are extracted with a minimum of drilling and blasting by undercutting the ore body, then blasting out the supporting columns and allowing the ore to break down from its own weight.

The diagrams, page 17, illustrate the progressive steps in mining asbestos by the block caving method.



An open pit asbestos mine



This large jaw crusher is typical of those used for primary crushing of the asbestos-bearing rock

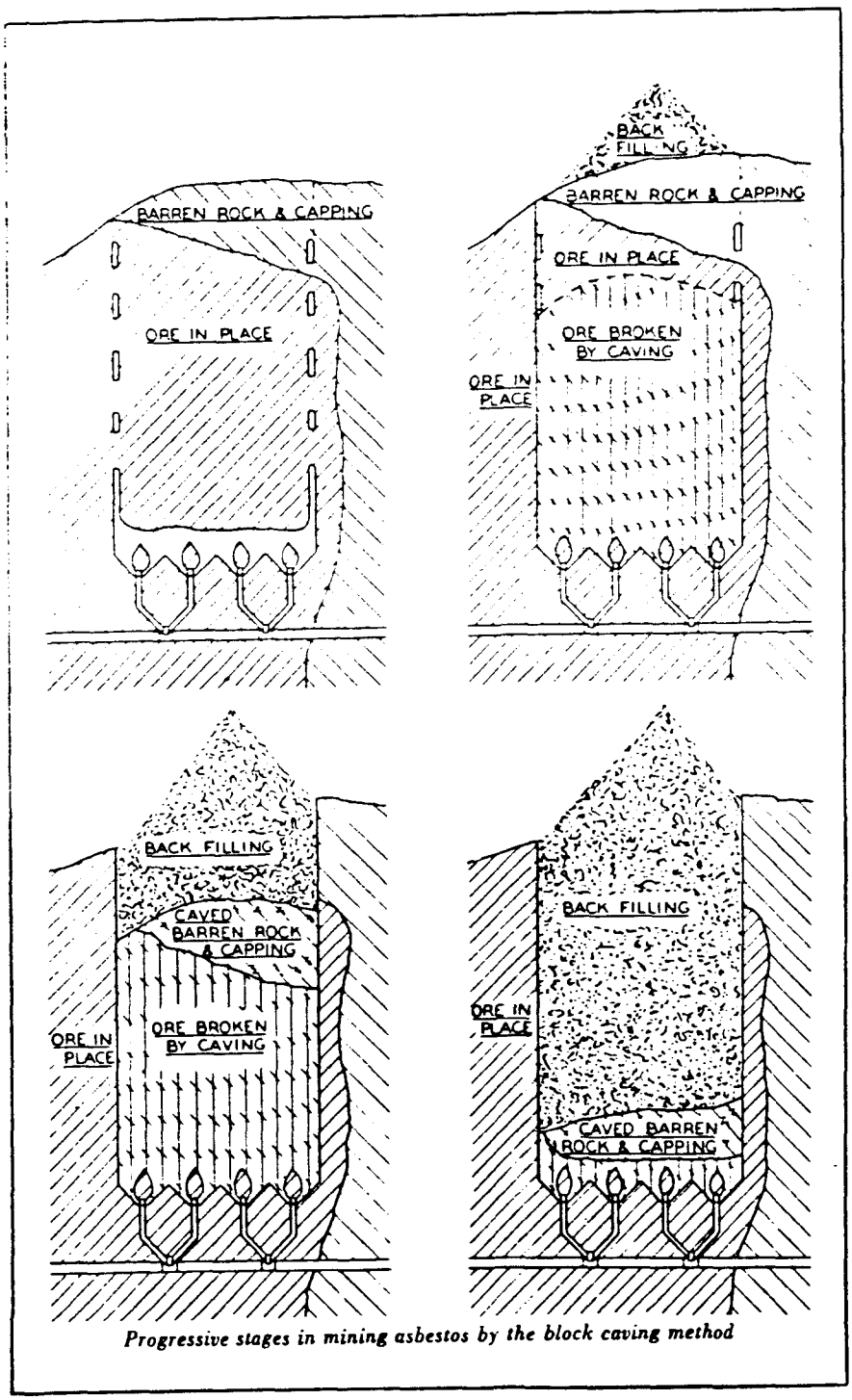
The percentage of fiber recovered from the ore is relatively small, the yield from Canadian mines ranging from three to ten percent depending upon the locale and the desired objectives of the operations. This means that from ten to more than thirty tons of asbestos-bearing rock must be mined in order to produce a single ton of usable fiber, most of which, however, is of insufficient length for spinning.

Of the total tonnage of chrysotile asbestos fiber extracted from Canadian mines during 1964, only about two and one-half percent consisted of grades that were suitable for processing into textiles.

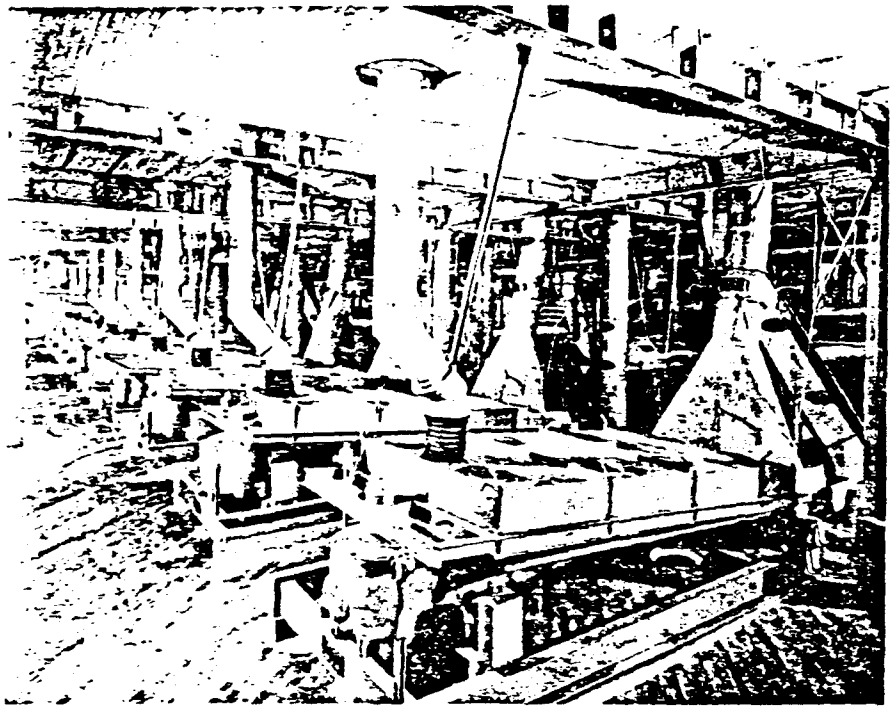
MILLING

Most of the textile fibers produced from the Canadian chrysotile deposits are recovered by mechanical milling and are known as milled fibers. The process is essentially one of freeing the fibers from the mother rock and consists of several stages of crushing, each of which is followed by screening and air separation. Although the fibers are tough and strong, specially designed crushing machines and techniques are employed to minimize fiber damage.

Enormous jaw crushers, some with a capacity of more than 250 tons of ore per hour, are used for the primary crushing. Secondary crushers,



Progressive stages in mining asbestos by the block caving method



Shaker screens with suction hoods which lift the asbestos fibers after crushing

usually of the gyrating type, effect a further reduction in the size of the ore particles. Other types of crushers and fiberizers are used for additional size reduction and opening up of the fibers.

Separation is accomplished by passing the mixture of rock fragments and asbestos fibers over large inclined shaking screens. The smaller pieces of rock and the shorter fibers fall through the screen openings and are carried away for further treatment. As the coarser rock particles and the longer fibers near the end of the screen, they pass under powerful suction hoods. These, functioning like oversized vacuum cleaners, lift the lighter freed fibers but leave the heavier rock particles and the still unopened fibers on the screen. The crushing and screening operations are repeated until all of the fibers have been separated and only waste rock remains.

After separation, the fibers are further opened, cleaned, graded according to length and bagged in 100 lb. bags for shipment. Although prepared to a considerable extent by the milling process, they require additional treatment at the textile plant before they are suitable for spinning.

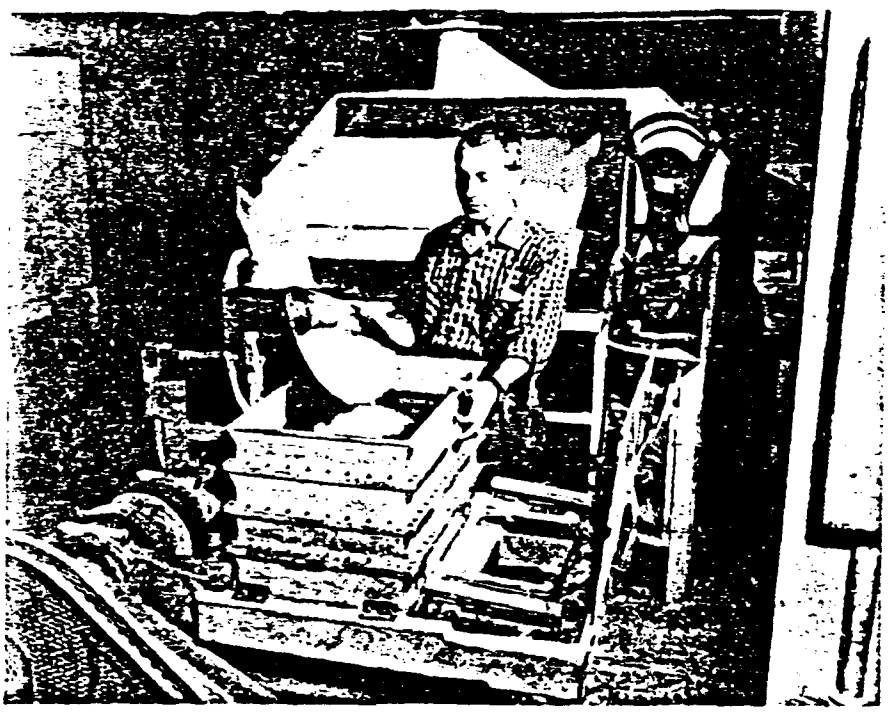
COBBING

A small percentage of textile fibers (those ranging in length from ¾″ to 3″ and longer) are not recovered by the mechanical milling process described above. Known as crude fibers, these grades are separated by hand cobbing with a hammer in order to better preserve the long fibers intact. Crude fibers, which are in the form of small unopened bundles, must be fiberized at the textile plant.

GRADING AND TESTING

Since the end uses of asbestos fibers are governed primarily by their length, it is important that they be carefully and accurately graded at the mill.

Standard methods of grading chrysotile fibers according to their length have been adopted and generally accepted by the American asbestos industry. The Quebec Standard Screen Test, used by the Quebec producers, employs a machine consisting of three rectangular screens held in frames measuring 24½″ by 14¾″ by 3½″ deep, one above the other. The top



Operator placing fiber sample in testing machine preparatory to conducting Quebec Standard Screen Test

screen is the coarsest, the middle screen is of intermediate size and the bottom screen is the finest. Under the bottom screen is a box for collecting the fibers that pass through all three of the screens. The screens are made to the following specifications:

Screen	Screen Opening	Diameter of Wire
Top—(Box No. 1)	0.500"	0.105"
Middle—(Box No. 2)	0.187" (4-mesh)	0.063"
Bottom—(Box No. 3)	0.053" (10-mesh)	0.047"

To conduct a test, 16 ounces of fiber are placed on the top screen. The lid is closed and the nest of screens is shaken horizontally at 327 rpm for 600 revolutions. The fiber grade is then determined on the basis of the number of ounces remaining on each of the screens and in the collecting box. Thus, if two ounces remain on the top screen, eight ounces on the intermediate screen, four ounces on the bottom screen and two ounces in the box, the fiber is known as 2-8-4-2, one of the spinning grades and is classified as 3T fiber.

Other methods of testing are also in use. These include the use of the Bauer-McNett Classifier and the Modified Suter-Webb Comb Sorter.

TEXTILE GRADES

Canadian Chrysotile: Only the longer, costlier grades of Canadian chrysotile fibers are used in the processing of asbestos textiles.

The standard Quebec classifications are as follows:

Group	Grade Designation	Fiber Length			
Group No. 1	Crude No. 1	¾" and longer			
Group No. 2	Crude No. 2	⅜" to ¾"			
Group No. 3	Spinning Fibers (milled)	Guaranteed Minimum Shipping Test[1]			
	3F	10.5	3.9	1.3	0.3
	3K	7.0	7.0	1.5	0.5
	3R	4.0	7.0	4.0	1.0
	3T	2.0	8.0	4.0	2.0
	3Z	1.0	9.0	4.0	2.0

[1]See "Grading"

Following are the grade classifications in use at the British Columbia mines:

Crude No. 1—basically of crude ¾" staple and longer
AAA—extra long textile fiber
AA—long textile fiber
A—textile fiber

African Chrysotile: The Rhodesian milled textile grades are as follows:

C&G/1—a textile fiber equivalent to Canadian 3F
C&G/2—a textile fiber equivalent to Canadian 3K
C&G/25—a textile fiber equivalent to Canadian 3R
C&G/29—a textile fiber equivalent to Canadian 3T

Note: Chrysotile is also produced as shorter milled fibers, which are suitable for numerous commercial uses but are not of sufficient length for processing into textiles.

Crocidolite: Fully fiberized crocidolite has a much greater volume than chrysotile and, to save excessive transportation costs, it is usually supplied in a semi-milled condition. For this reason it is classified on the basis of length of fiber in the seams or in the unmilled cobs from which the various grades are obtained. Control of quality is normally achieved by comparison with standard or "umpire" samples supplied at regular intervals from the mills.

Following are the standard grades of Cape blue (Union of South Africa):

Grade	Approx. Length Range of Unmilled Fiber
S	Up to ½"
A	½" to ¾"
B	¾" to 1¼"
C	Over 1¼"

The following grades of Transvaal blue are as given by the Department of Mines, Union of South Africa.[2]

Crude	Fiberized	Length of Fiber
TX	TDX	Plus 1½"
T1	TD1	⅞" to 1½"
T2	TD2	½" to ⅞"
T3	TD3	¼" to ½"
T4	TD4	Minus ¼"

[2] "Asbestos Grades in South Africa," Asbestos, December, 1948

Amosite: For the same reason as stated under "Crocidolite" above, amosite is also supplied in a semi-milled condition and classified on the basis of length of fiber in the seams or unmilled cobs from which the various grades are obtained. Control of quality is also achieved by comparison with standard or "umpire" samples, supplied at regular intervals from the mills.

Fibers from the various mining properties in the Transvaal are graded as shown below:

Grade	Approx. Length Range of Unmilled Fiber	Designation	Color
D3	2" to 6"	Long	Gray
LD3	2" to 6"	Long (part fiberized)	Gray
D11	1" to 2"	Medium Long	Gray
DX	1" to 2"	Medium Long	Gray
MD	¾" to 2"	Medium	Gray
M	¾" to 2"	Medium	Gray
K3	½" to 2"	Medium Short	Gray
W3	½" to 2"	Medium Short	Gray
SK	3/16" to 1"	Shorts	Gray
SW	3/16" to 1"	Shorts	Gray
S2	3/16" to 1"	Shorts	Gray
GK	⅛" to ¾"	Shorts (part fiberized)	Gray
GW	⅛" to ¾"	Shorts (part fiberized)	Gray
S33	⅛" to ¾"	Shorts (part fiberized)	Gray

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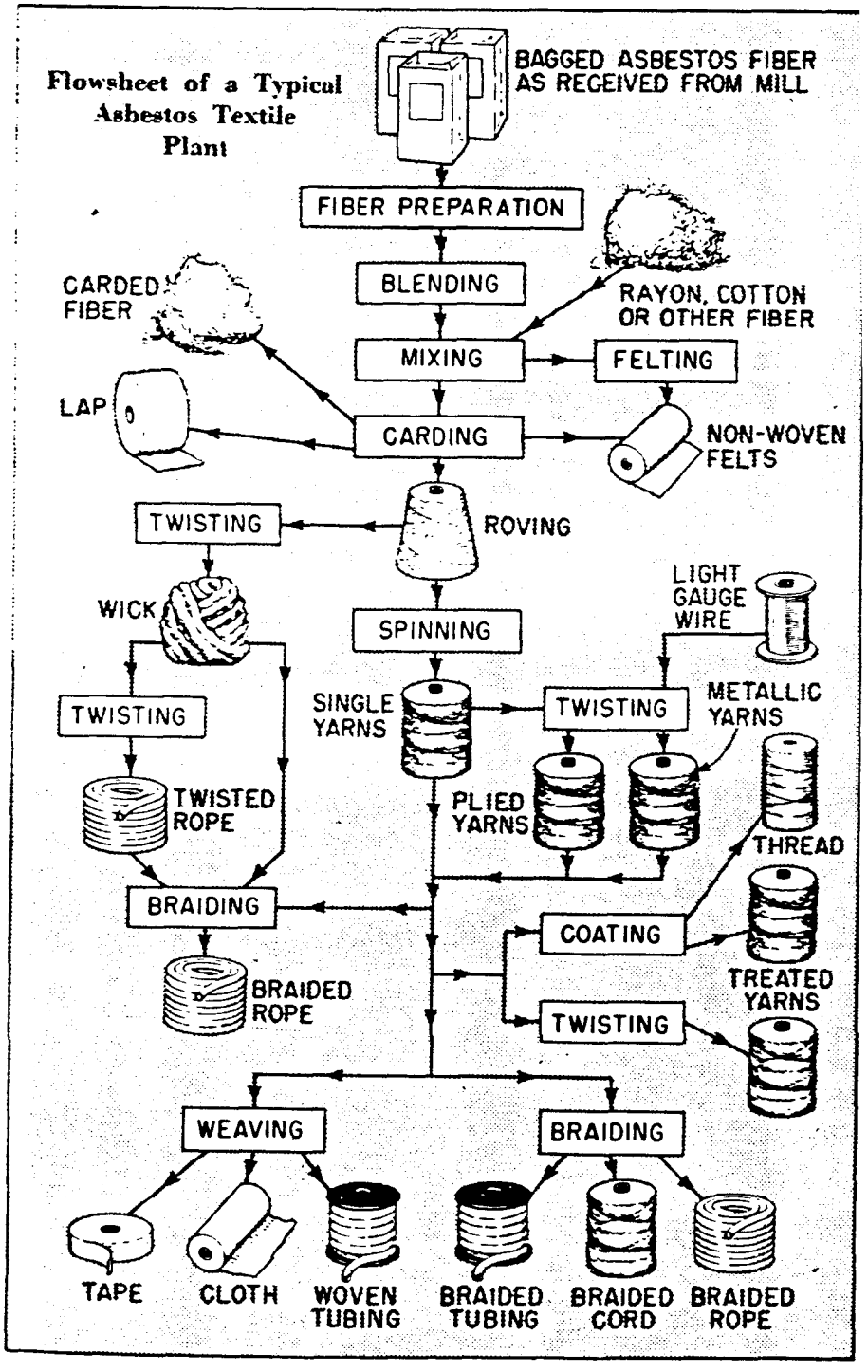

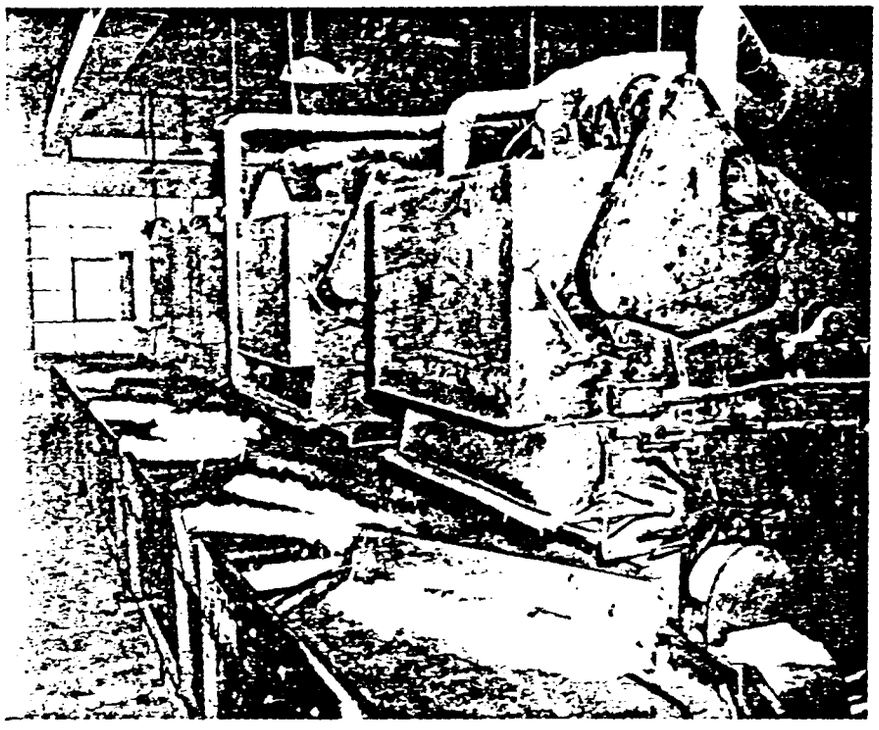

Automatic blending units of the type shown here insure the exact percentages of asbestos and other fibers required for each specific end product

Processing Asbestos Textiles

ASBESTOS textiles are produced in modern textile plants by processes which are not unlike those utilized in the manufacture of textiles made from cotton or wool. The successive operations and resultant finished products are shown on page 23 in the flowsheet diagram of a typical asbestos textile plant.

FIBER PREPARATION

The asbestos fibers are received at the textile plant in a fully opened or semi-opened condition. Specially designed opening equipment is used to remove short fibers and to give additional opening when required. The machinery employed for this purpose includes vertical openers, carding willows, box top willows and other devices.



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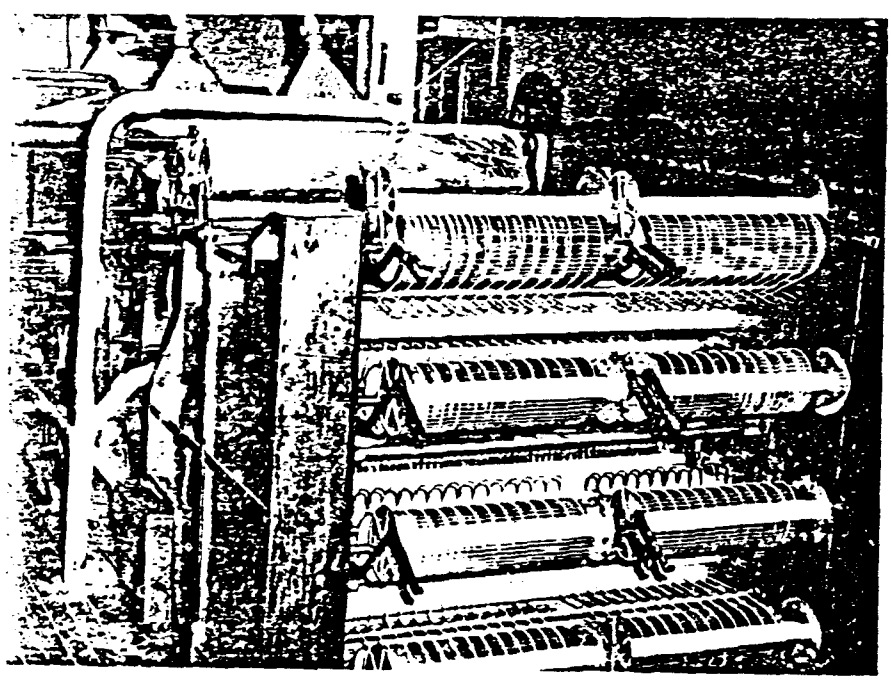
BLENDING AND MIXING

After fiber preparation, the next step is blending and mixing. The composition of the blends and fixing of the formulation are governed by the characteristics of the fiber, manufacturing possibilities, the requirements to be met by the finished product and the intended use. Small percentages of cotton, rayon and other natural or synthetic fibers are added to improve spinnability and to impart the desired serviceability to the end product.

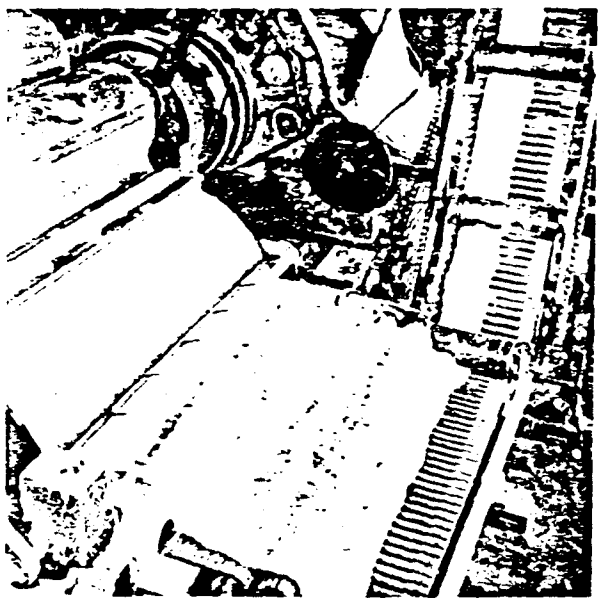
Multi-hopper automatic blending units containing several hopper feeds are employed for the blending and mixing of asbestos and organic fibers.

CARDING

This operation, similar to that employed in the processing of wool, completes the opening and cleaning of the fibers. Under the teasing action of thousands of needle-pointed wires which form the working face of the "clothing" that covers the cylinders of the carding machine, the fibers are combed into a relatively parallel arrangement, forming a tenuous web. This web, or sliver as it is called, becomes roving when separated into ribbons, rubbed mechanically and condensed into untwisted strands. Roving is the asbestos textile product from which yarns are produced.



An asbestos carding machine showing roving being wound on jack spools



The tenuous web of asbestos fibers from breaker card (foreground) passing over camel back to finishing card

SPINNING, TWISTING AND FORMING

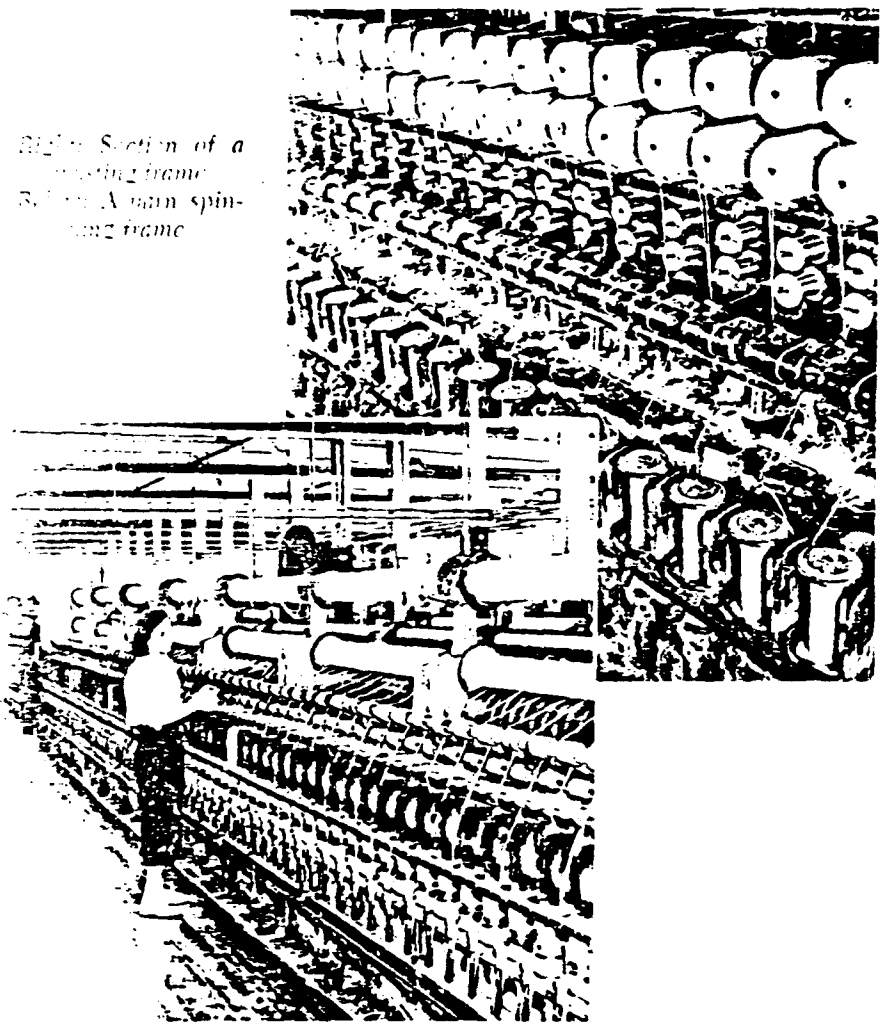
The previously carded strands of roving are spun into yarn in much the same manner as cotton and woolen yarns are produced. The spinning process is essentially one of imparting a twist to the roving in order to provide tensile strength and facilitate further processing. The resultant product is known as a single yarn. When single yarns are twisted together to produce larger, stronger yarns, the process is known as twisting or plying.

Forming is a term applied to twisting single yarns into plied yarns by means of a tubing twister. A tubing twister feeds two or more single yarns of exactly equal length to the spindle, and plies them into a cord having exceptional uniformity and maximum tensile strength. This is done by having the single yarns under equal stress so that each contributes its maximum individual tensile to the strength of the cord.

The asbestos yarns produced by spinning, twisting and forming are made in various sizes and plies and serve as the basic components in the fabrication of many other asbestos textile products, both woven and braided.

WEAVING

Asbestos yarn is woven into cloth on looms similar in principle to those used for weaving other types of fabrics. The designated number of strands



Right: Section of a ... spinning frame
Below: A ... ring spinning frame

of warp yarn are threaded through the heddles and the reed of the loom and sufficient yarn is wound on quills and placed in the shuttle for the filling. The warp yarns (ends) run longitudinally or parallel to the selvage edges of the fabric, while the filler yarns (picks) interweave these together transversely. The construction of the cloth is controlled by regulating the number of ends and picks per inch.

Techniques of processing have been developed to such an extent that a large variety of woven products now come from the looms of asbestos textile manufacturers. Fabrics can be woven in flat or tubular shapes and are available in a wide range of textures, weaves, weights and thicknesses.

BRAIDING

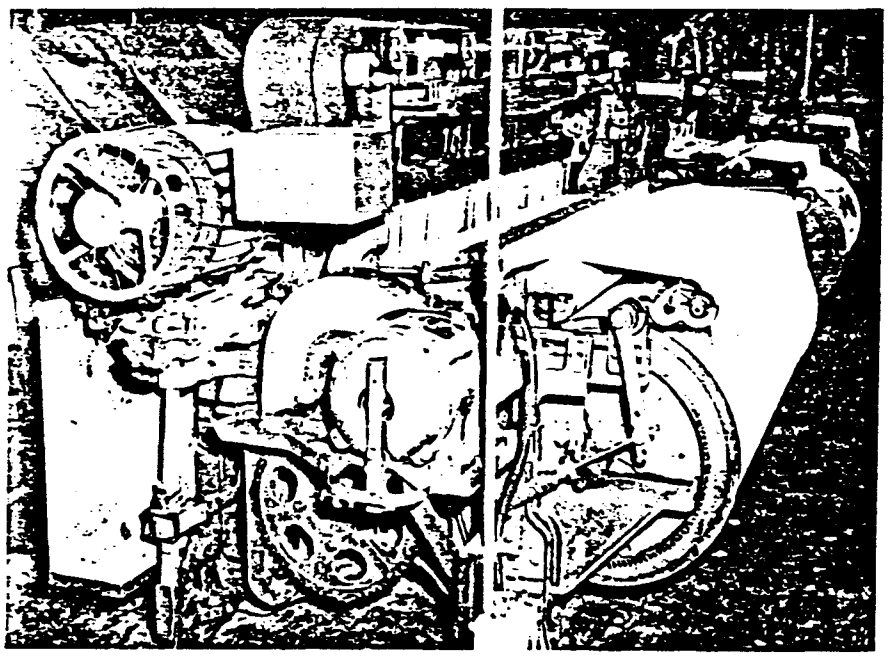
The braiding process is done from a series of yarn-carrying spindles, half of which travel in one direction and half in the opposite direction. The action is similar to that in a maypole dance, the yarns being plaited together to form a braided product. Many kinds of braids, both round and square, may be produced by varying the number of ends of yarn wound parallel on the braider tube, by changing the tension applied and by adding mechanical attachments to the braider.

FELTING

Felting is the process of arranging asbestos fibers or a mixture of asbestos and other fibers to produce a uniform, continuous non-woven sheet. The fibers may have random or parallel orientation. Special binders may be added to provide fabrication strength or other desired properties.

INSPECTION AND QUALITY CONTROL

During their manufacture, asbestos textiles are carefully tested for strength, weight, asbestos content and other qualities that are important in the service in which they are to be used. Before packaging, the finished products are given a final inspection to insure that the quality standards established by the manufacturer have been met.



A loom of the type used for weaving asbestos cloth

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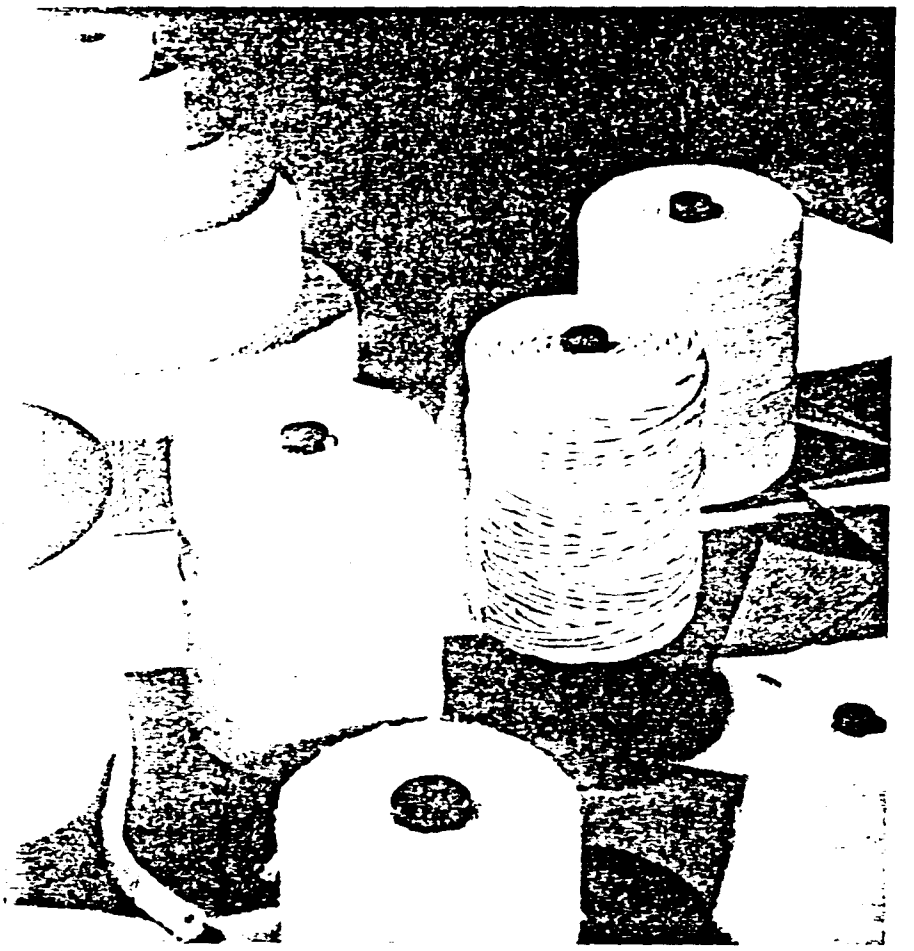
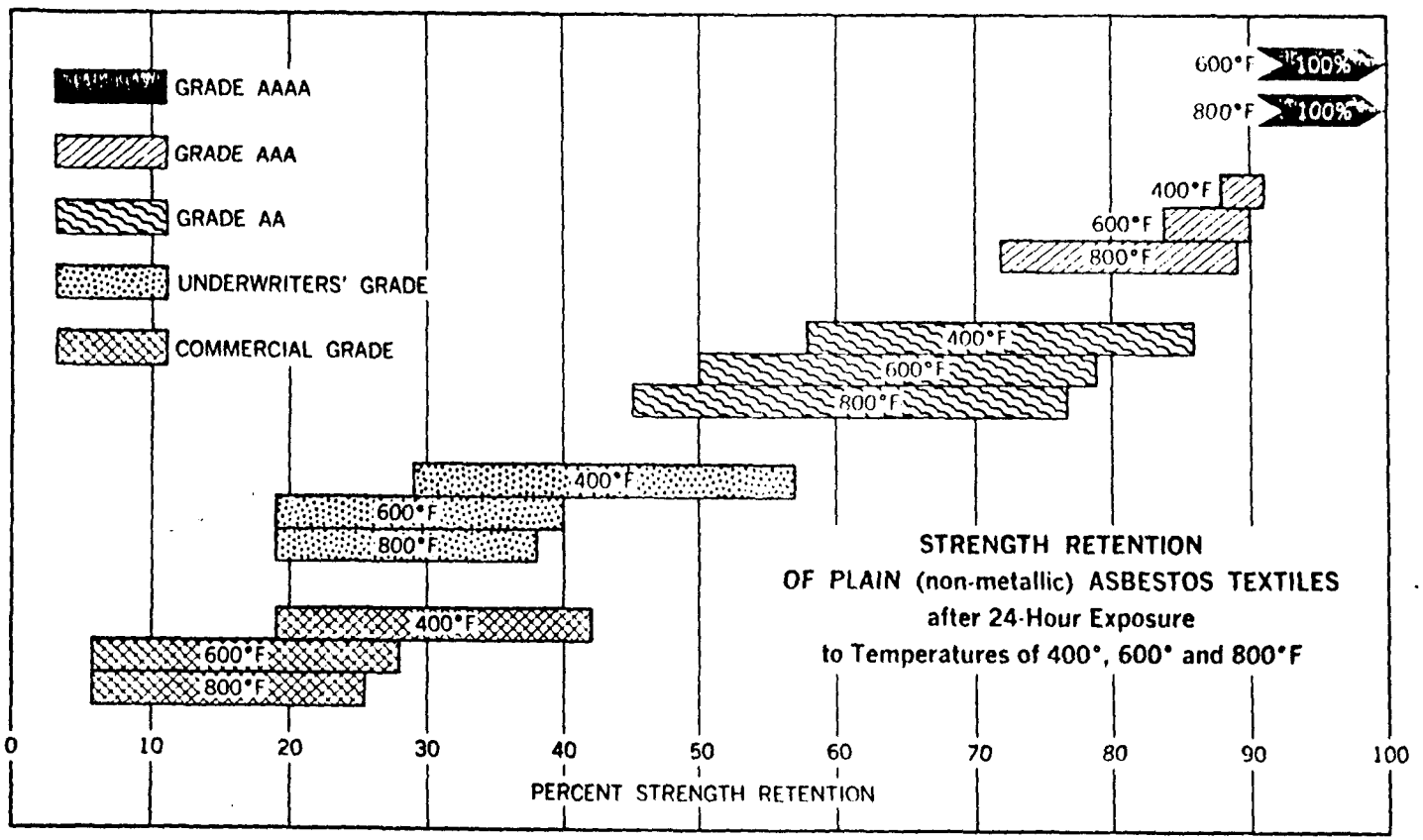


Asbestos Textile Products

The following pages contain information about the products made from chrysotile asbestos fibers by the asbestos textile industry. This includes significant test results on strength retention and other properties at elevated temperatures. (See "Elevated Temperature Serviceability," page 31.) Also included is a description of each product and how it is made, together with pertinent data regarding styles, sizes, grades, weights, etc., and a short summary of established uses. Further information, as well as helpful assistance in selecting asbestos textiles for specific applications may be obtained from any of the member companies of the Asbestos Textile Institute.

CHART A


GRADE AAAA
GRADE AAA
GRADE AA
UNDERWRITERS' GRADE
COMMERCIAL GRADE
600°F 100%
800°F 100%
400°F
600°F
800°F
400°F
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STRENGTH RETENTION
OF PLAIN (non-metallic) ASBESTOS TEXTILES
after 24-Hour Exposure
to Temperatures of 400°, 600° and 800°F
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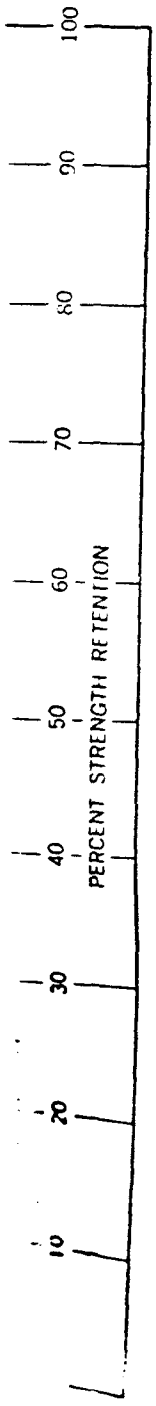
70
80
90
100
PERCENT STRENGTH RETENTION



ELEVATED TEMPERATURE SERVICEABILITY

Asbestos textiles, used alone or in combination with other materials, find many specialized uses, not only in the moderate temperature field (up to 1200° F.), but also in applications where temperatures in excess of 5000° F. are encountered for periods of short duration.

Plain (non-metallic) Asbestos Textiles – through 900° F: There are two coherent factors which have an important bearing upon the serviceability of plain asbestos textiles at elevated temperatures:

1. The percentage of asbestos in the textile
2. Its design and construction

Resistance to degradation by heat is largely a function of the asbestos content: the higher the percentage of asbestos fiber, the higher the serviceability at elevated temperatures. Design and construction, however, also influence high temperature serviceability. In general, those textiles which are composed of the finer cut yarns will exhibit the highest strength retention characteristics, since these finer yarns contain greater amounts of the long fiber grades of asbestos.

Chart A shows the results of 400° to 800° F range tests of strength retention characteristics made with various grades of plain asbestos fabrics over a 24-hour test period. In interpreting these data, the upper values within each given bar unit should be considered representative of textiles composed of finer cut yarns. As the number of yarn cuts decreases, the tensile strength retention will also decrease within the ranges shown.

It is also important to remember that the time factor has a direct bearing on the percentage of strength retention. As the elevated temperature period is shortened, the percentage of strength retained is correspondingly increased. This principle is made use of in many practical applications where asbestos textiles are exposed for shorter periods to temperature ranges greatly in excess of those under discussion here. Conversely, the percentages shown in Chart A represent degradation values approximately 85% to 90% of what would be expected in extremely long range service over periods of several weeks or months of exposure.

Metallic (wire-inserted) Asbestos Textiles – through 1200° F: These materials, fabricated with an insert of wire, further extend the temperature serviceability range. Their strength retention characteristics are higher than those for plain (non-metallic) asbestos textiles and in addition, they offer greater resistance to abrasion.

Laminated and Bonded Asbestos Textiles – through 5000° F: In the realm of ultra high temperatures, asbestos textiles, combined with resins

and ceramic binders, provide a construction possessing a unique combination of properties for applications through 5000° F. These properties include low thermal conductivity and diffusivity, uniform ablation, excellent dimensional stability and high resistance to thermal shock. Particularly outstanding is the low erosion rate of impregnated asbestos textiles at elevated temperatures. As an example, studies indicate an erosion rate at approximately 4000° F for a phenolic resin impregnated asbestos felt of 2 mils per second as compared to 8 mils per second for boiler plate steel.

The low thermal conductivity of these impregnated materials is illustrated in Table L, which presents significant comparative data accumulated by two different test techniques at temperatures of 4000° and 4500° F. Column A shows the results obtained when ½" thick samples of the materials under test were exposed to a gas-oxygen flame at 4000° F and the time required to attain a temperature of 360° F on the opposite side of each sample was determined. Column B shows the comparative temperatures on the side away from the flame after a 60 second exposure at 4500° F. The superiority of the felted asbestos laminate as a thermal insulator at these elevated temperatures is clearly apparent.

TABLE L

	A Time Required for Side Away from Flame to Reach 360°F	B Temperature Reached On Side Away from Flame After 60 Sec. Exposure
Phenolic Laminated Asbestos Felt	82 seconds	220°F
Phenolic Laminated Chopped Glass	50 seconds	600°F
Phenolic Laminated Glass Cloth	28 seconds	1400°F

Further evidence of this property is illustrated by a commercial application in which the wall of a solid fuel rocket motor chamber was lined with a ½" thick phenolic resin impregnated asbestos felt. At the 5000° F operating temperature, this ½" thick insulation protected the wall for the 90 second duration life of the motor, at the same time resisting the destructive erosive action of the high velocity exhaust gases.

Recent developments have added a new group of ceramic bonded asbestos textiles for ultra high temperature service. These new materials are formulated and fabricated by impregnating asbestos textiles with specially compounded ceramic metallic oxides and silicates. The resulting products are

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erviceable at temperatures above 3000° F and are lighter in weight and will withstand more physical abuse than conventional ceramic products.

RADIATION STABILITY

The exceptionally good resistance of asbestos to nuclear radiation indicates that this fiber, either in textile form or as a reinforcing agent in an appropriate matrix, will have important applications in environments exposed to such radiation.

Studies have shown that asbestos fibers can withstand an integrated epithermal neutron flux of approximately 10^{20} NVT before significant structural changes occur.

GRADES

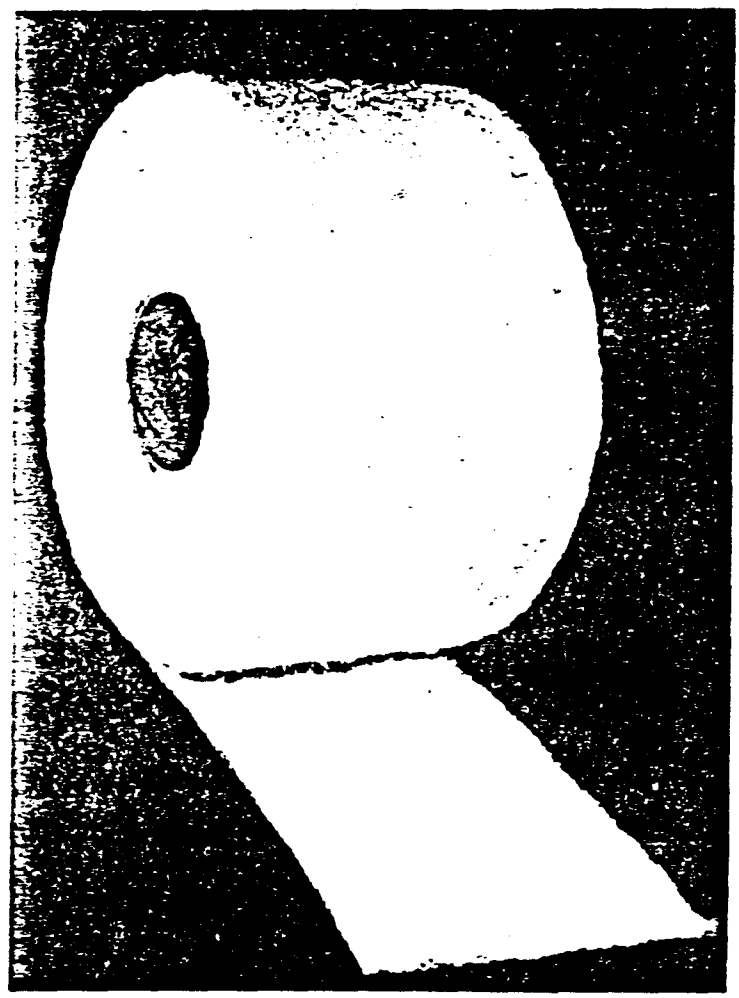
The word "grade" as used in the asbestos textile industry indicates a system of classification based on the percentage of asbestos by weight in the finished product. In Table K are listed the standard grades with the percentage of asbestos content for each grade.[1] This method of grading applies to all products described on the following pages except carded asbestos fibers, although not every product is manufactured in every grade. The available grades will be found listed under each product.

TABLE K
PERCENTAGE OF ASBESTOS CONTENT BY WEIGHT IN ASBESTOS TEXTILE PRODUCTS

As Established by the American Society for Testing and Materials

GRADE	ASBESTOS CONTENT BY WEIGHT
Commercial	75% up to but not including 80%
Underwriters'	80% up to but not including 85%
Grade A	85% up to but not including 90%
Grade AA	90% up to but not including 95%
Grade AAA	95% up to but not including 99%
Grade AAAA	99% up to and including 100%

[1]See ASTM Specification D 1918, page 92, for the test methods used to determine asbestos content (grades).



Asbestos Lap

Asbestos lap is a felted form of carded asbestos fibers which have been blended with organic fibers. It is furnished in two styles: Style I, a single ribbon-like formation of fibers, and Style II, a paralleled assemblage of Style I lap.

Uses: A specialized product made for the electric wire and cable industry, asbestos lap is designed for re-carding into an insulation for heater cords, fixture wires and other electrical conductors. The re-carded laps are spiraled around the conductor to form a homogeneous wall of asbestos

...ers which serve as a carrier for the electrical insulating compounds. The ...mployment of asbestos to completely envelop certain types of copper ...res which may be exposed to severe heat has long been a requirement ...the National Electrical Code in the interest of preventing electrical fires.

...ades, Weights: Asbestos lap is made in the following standard ASTM ...ades: Underwriters', A, AA and AAA. (See Table K, page 33. for per...ntage of asbestos content in each grade.) It is supplied in unit rolls ...nging from 250 to 4200 grains[2] per linear yard.[3]

...lectrical Insulation Classification: Asbestos lap as made for the elec...rical industry is furnished in three types, classified on the basis of mag...etic rating determinations[4] which serve to identify performance limits.

Type II – Magnetic Rating 0.75 Maximum
Type IV – Magnetic Rating 2.00 Maximum
Type VI – Magnetic Rating 4.00 Maximum

Type II is intended only for special applications where the asbestos is of primary importance as electrical insulation used on magnet wire and when used primarily as a dielectric.

Type IV is intended for use where the asbestos is of secondary importance as electrical insulation and where it is applied in combination with other materials of comparably higher dielectric strength, as in the construction of heat and flame resistant electrical insulating walls over unit conductors of electric cables.

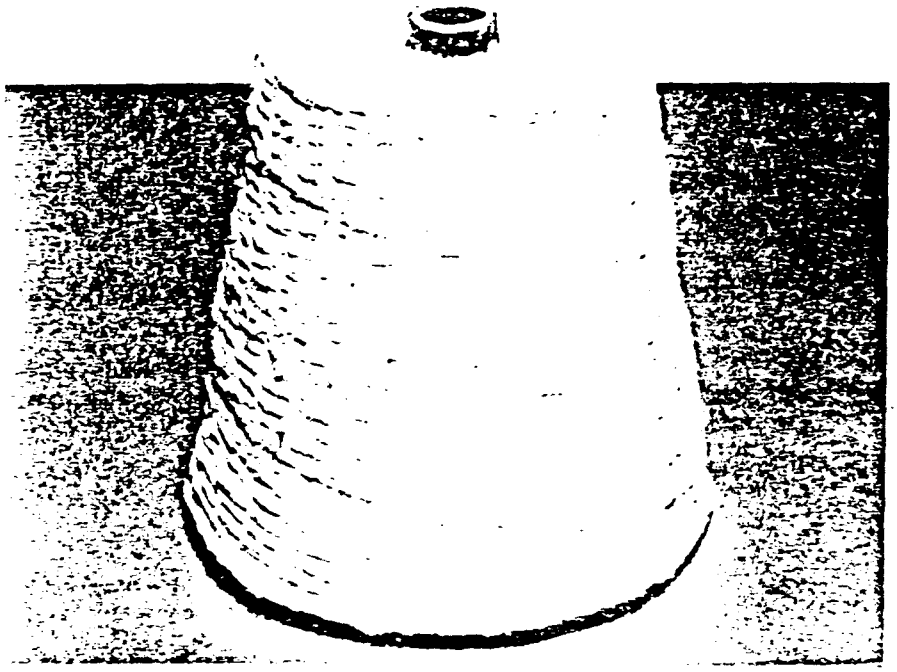
Type VI is intended for use where the asbestos is of minor importance as a dielectric, as in the construction of filler or heat and flame resistant walls of electric cables or when used as a lining for control enclosures subject to exposure to electric arcs.

Standard Packages: Asbestos lap, wound on paper tubes, is packaged in rolls which vary in size in accordance with the number of slivers in the assemblage.

[2]Grain: a unit of weight. 7000 grains = 1 pound.

[3]For permissible weight variations, methods of test and other detailed information about asbestos lap not given above, see ASTM Specification D 1061, reproduced on pages 60 and 61 of this Handbook.

[4]See ASTM Specifications D 2100, page 78, and D 1118, page 81.



Asbestos Roving

Asbestos roving is an assemblage of carded asbestos fibers blended with cotton or other organic fibers and condensed into a single strand without twist. It is produced in various degrees of density from a soft, fluffy roving to a firmly compacted one, to meet specific requirements of the user.

Reinforced roving (also known as core or inserted roving) is similar to the plain roving described above but has a core of cotton or other thread to give it added tensile strength.

Uses: Asbestos rovings were developed for the electric wire industry to serve as insulation for heater cords, cables and electrical heating elements and are extensively used for this purpose. The strands are wrapped or "served" by wire covering machines to form a relatively soft, complete sleeve over the wire.

Grades: Asbestos roving is supplied in five standard ASTM grades: Underwriters', A, AA, AAA and AAAA. (See Table K, page 33, for percentage of asbestos content in each grade.)

Size or Cut: The size of asbestos roving is denoted by the "cut" number which, when multiplied by 100 indicates the approximate number of

...rds per pound. Standard cut numbers, with nominal yards per pound ...d permissible variations are shown in Table I, ASTM Specification ...875 reproduced on page 63.

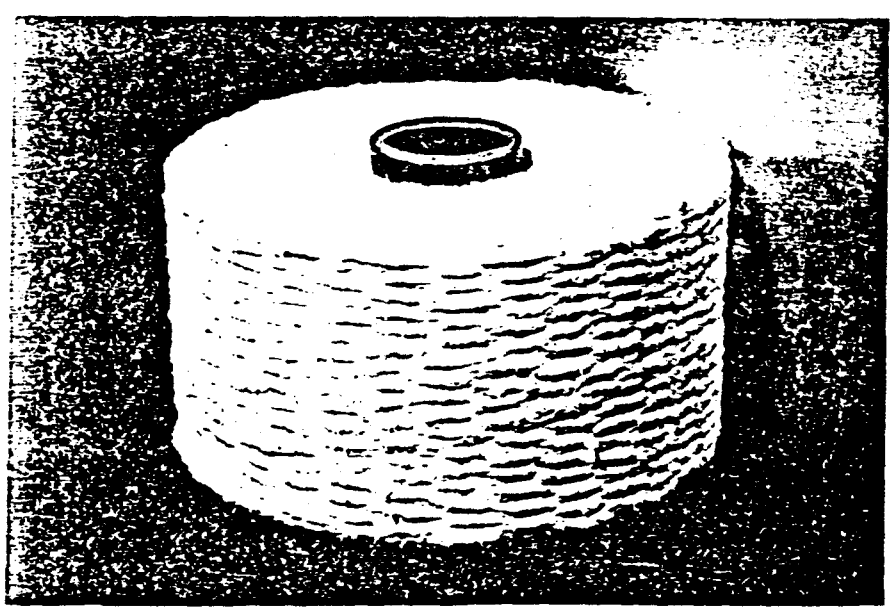
...lectrical Insulation Classification: Asbestos roving as made for the ...ectrical industry is furnished in three types, classified on the basis of ...agnetic rating determinations[5] as follows:

...pe II (Magnetic Rating 0.75 Maximum) is intended only for special ...plications where the asbestos is of primary importance as electrical in...ulation used on magnet wire and when used primarily as a dielectric.

...pe IV (Magnetic Rating 2.00 Maximum) is intended for use where ...he asbestos is of secondary importance as electrical insulation and where ...t is applied in combination with other materials of comparably higher ...dielectric strength, as in the construction of heat and flame resistant elec...trical insulating walls over unit conductors of electric cables.

Type VI (Magnetic Rating 4.00 Maximum) is intended for use where the asbestos is of minor importance as a dielectric, as in the construction of filler or heat and flame resistant walls of electric cables or when used as a lining for control enclosures subject to exposure to electric arcs.

Standard Packages: Asbestos roving is wound on cones and tubes of various sizes in accordance with customer requirements.



[5]See ASTM Specifications D 2100, page 78, and D 1118, page 81.

...ss. Metallic yarns are widely used in asbestos textiles where the ... product requires unusually high tensile strength, exceptional re...ance to heat or abrasion, or a combination of these properties.

...ss C: Organic Reinforced Asbestos Yarn is plain asbestos yarn with an ...rt of yarn made of other fibers, usually cotton and/or one of several ...thetic organic fibers. Reinforced yarns, also referred to as inserted ...rns, are particularly adapted to the braiding and weaving processes ...use of their increased tensile strength.

...ss D: Inorganic Reinforced Asbestos Yarn is plain asbestos yarn con...ing non-metallic reinforcing strands such as glass fiber yarns.

...lass E: Combination Yarns are asbestos yarns constructed of two or ...re of the yarns described in Classes A through D, or yarns containing ...nforcing members from two or more of Classes A through D.

...ngle and Plied Yarns: Asbestos yarns are produced as both single and ...ed yarns. Plied yarns consist of a number of strands of single yarns ...sted together to form a heavier yarn of greater strength.

Treated Yarn: For special purposes, asbestos yarns are also coated or impregnated with various compounds to lay the fibers or increase tensile strength or impart other properties. These are known as treated yarns.

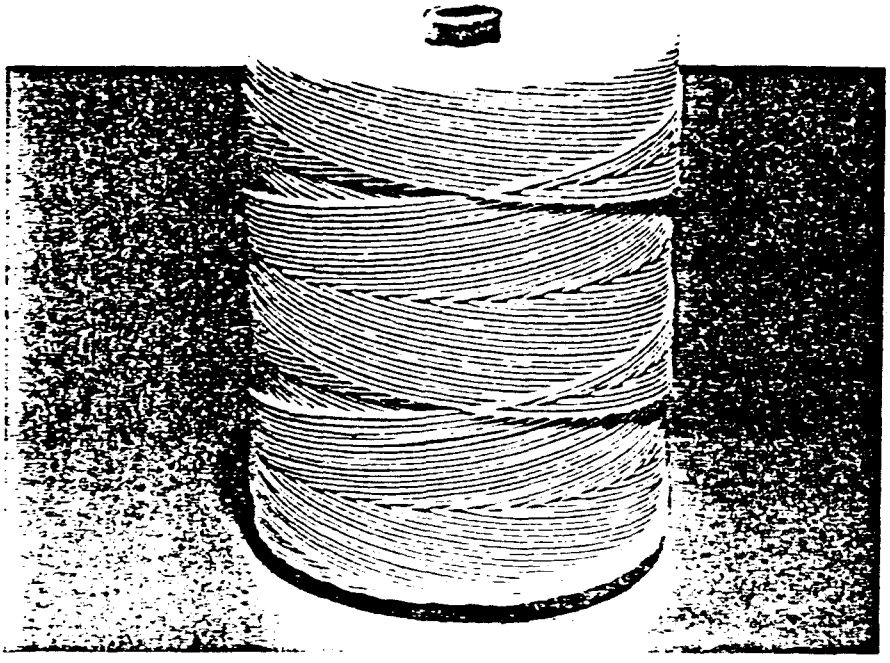
Grades: Asbestos yarns are made in all standard ASTM grades as follows: Commercial, Underwriters', A, AA, AAA and AAAA. (See Table K, page 33, for percentage of asbestos content in each grade.)

Direction of Twist: Asbestos yarns are spun with "S" and "Z" twists. (See Glossary, page 99.)

Cut of Yarn: The term "cut" refers to the number of 100 yard lengths contained in a pound. (See also "Cut, Asbestos" in Glossary, page 97.)

Yarn Numbers: In the asbestos textile industry, the yarn numbering system used designates the cut, number of plies, and whether the yarn is plain or contains a metallic insert. In a four digit figure, the first two digits indicate the cut, the next digit indicates the number of plies and the final digit indicates the number of metallic strands. If the final digit is a zero, it indicates a plain (non-metallic) yarn. For example, No. 2430 is a 24-cut, 3-ply plain yarn. No. 1022 is a 10-cut, 2-ply metallic yarn containing two wires as the metallic inserts. In a three digit figure, the first digit indicates the cut. Thus, No. 810 is an 8-cut single ply plain yarn.

Standard Packages: Asbestos yarns are wound on paper tubes or cones. Various size packages are available to meet the user's requirements.



Asbestos Cord

TWISTED asbestos cord is made of a predetermined number of strands of asbestos yarn tightly twisted together to form a cord of specified diameter and higher tensile strength. The yarn used may be single or plied, sized or unsized, or plain (non-metallic) or metallic (wire-inserted), depending on the end use of the product.

Braided asbestos cord is made by braiding one or more jackets over an asbestos yarn or cord core.

Uses: Because of their uniformity, strength and ability to withstand high temperatures with negligible structural change, asbestos cords have many specialized uses. They provide an ideal core for electric resistance wires and are widely employed as an insulation for glass handling tools, as a seal on high temperature corrugated metal gaskets, as a valve stem packing and as a braided wall in the construction of steam hose.

The metallic cords have inserts of fine wire and are designed for use under exceptionally severe conditions. They are especially suitable for flare signal cords and for such uses as suspending retorts, crucibles and other objects that are in contact with flame or heat.

Grades: Asbestos cord is made in all standard ASTM grades as follows: Commercial, Underwriters', A, AA, AAA and AAAA. (See Table K, page 33, for percentage of asbestos content in each grade.)

Sizes: Standard diameters of asbestos cord range from 1/16" up to 3/8".

Direction Of Twist: Asbestos cords are plied with "S" and "Z" twists. (See Glossary, page 99.)

Standard Packages: The form of package varies with the requirements of the customer. Fractions of a pound are usually packaged as balls; quantities of 1, 5 and 10 pounds are generally wound on tubes or spools; larger quantities up to 50 pounds are on spools or reels.

TABLE M—WEIGHTS AND FOOTAGES OF ASBESTOS CORD

Nominal Diameter Inches	Approx. Lbs. Per 100 Ft.	Approx. Ft. Per Lb.
1/16	.20	500
3/32	.40	250
1/8	.63	160
5/32	.95	105
3/16	1.43	70
1/4	2.00	50

Asbestos Thread

Asbestos thread is made by treating asbestos yarns with special compounds to lay the fibers and to produce an exceptionally smooth, uniform finish. It is produced in both plain (non-metallic) and metallic (wire-inserted) classes, the latter being noted for its great tensile strength and high thermal stability. It is adapted to either hand or machine sewing.

Uses: Because it possesses the advantages that are inherent in the inorganic mineral fibers from which it is made, asbestos thread can be used under conditions that would be destructive to thread made from organic fibers. Typical uses include sewing the asbestos fabrics used in the manufacture of theater curtains, belting and safety clothing; sewing insulation jackets on piping and turbines; wrapping electric resistance wires; and fastening the asbestos roving insulations at each end of heater cords.

Grades: Asbestos thread is generally furnished in Underwriters' grade.

Standard Packages: Asbestos thread is supplied wound on tubes as specified by the user.

Asbestos Cloth

Asbestos cloth is woven from five classes of asbestos yarns. The most widely used fabrics are woven from Class A (plain or non-metallic) yarns and Class B (metallic or wire-inserted) yarns. Other fabrics are made from Class C, D and E reinforced yarns as described in ASTM Specification D 1571, page 70. A wide selection of grades, weights and constructions is available and textures range from open-mesh to lightproof. The choice of weaves includes plain, twill, broken twill, satins and herringbones. Representative fabrics are shown on the following pages.

In addition to the standard asbestos cloths, specially treated cloths are made by most asbestos textile manufacturers to meet unusual conditions or to provide special characteristics such as resistance to extreme abrasion.

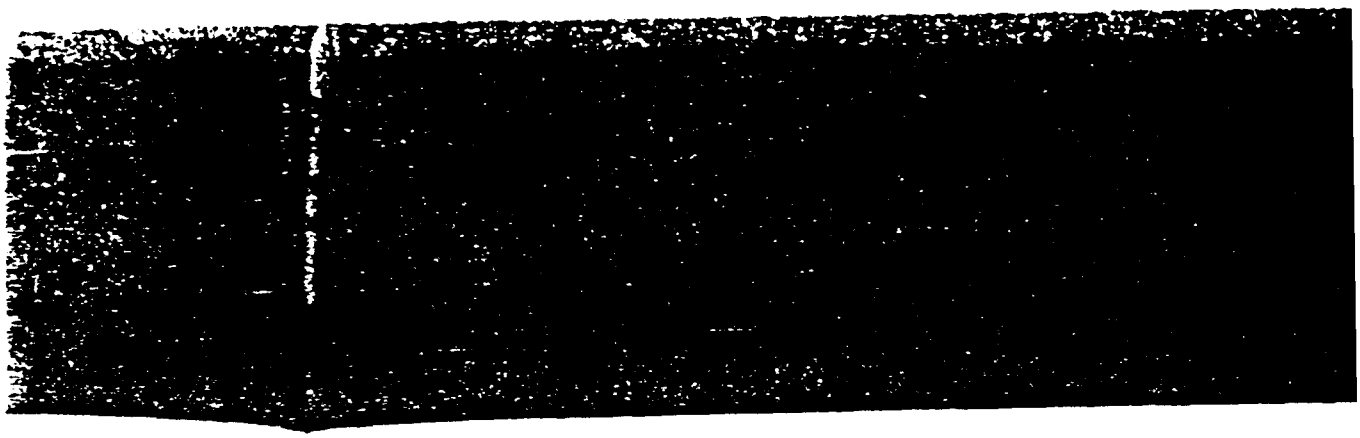
APPLICATIONS

Because of its inherent incombustibility and thermal stability, asbestos cloth is extensively used wherever these properties are essential in a fabric. Familiar examples are the asbestos safety curtains of theaters and auditoriums, flameproof draperies, fire-smothering blankets, and the safety clothing worn by members of the armed services and by industrial workers as protection from intense heat and flash burns.

Asbestos cloths with suitable treatments or coatings are widely used as the facings for conveyor belts handling hot materials; as covers for domestic ironing boards and commercial laundry flat work ironers; as gasketing material for high temperature and pressure boilers and pipe flanges; and as industrial furnace hoods, shields for welding booths and splash aprons.

Many government specifications, particularly those of the United States Navy, require that high pressure steam pipe insulation be protected by an outside jacket of asbestos cloth. Maritime specifications, and many industrial and utility power plants also require asbestos cloth to protect the insulation and to serve as a fireproof jacket over pipe and boiler insulation. Underground and overhead piping, both steam and refrigeration, as well as heating and ventilating ducts, are best protected by a jacket of asbestos cloth. Specially processed lint-free asbestos cloths also serve as protective shields in "clean" areas adjacent to nuclear reactors.

The dust bags for removing dust, fumes and vapors in mechanical dust collecting systems are among other specialized uses of asbestos cloths. In the glass industry they serve as lehr curtains and to prevent contact between molten glass and cold metallic surfaces. In the field of sound



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...specially fabricated asbestos cloths provide acoustical properties ...ch are utilized in reducing undesirable noise levels.

...eated Asbestos Cloth: To meet the special requirements of the plastics ...stry, asbestos cloths, impregnated with organic resins and press cured, ...de asbestos-base plastic parts having high impact resistance and ...ent flexural and tensile properties. The most commonly used resins ...e the phenolics, silicones, melamines and acrylics.

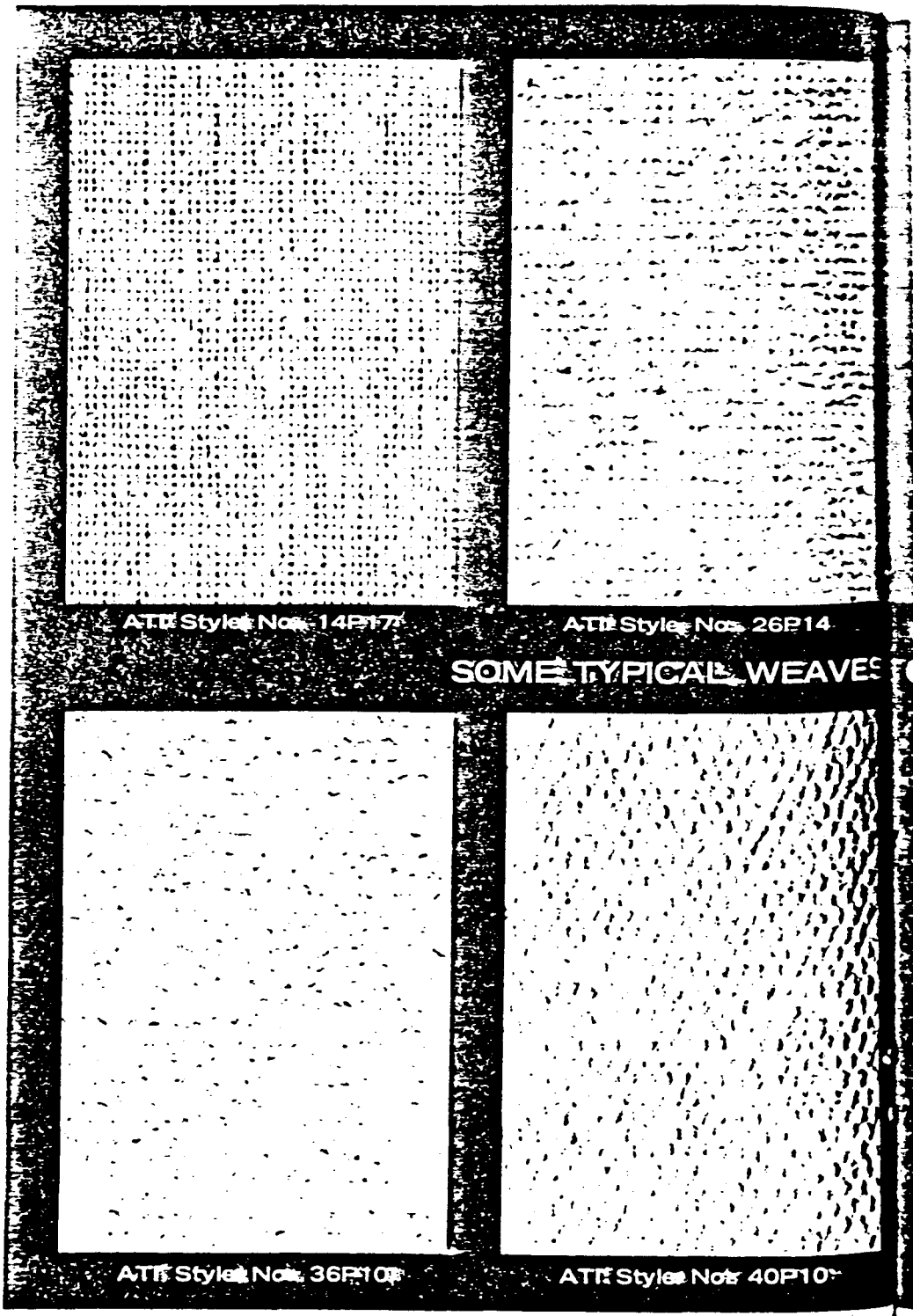
...e rocket and missile industries utilize resinated asbestos components ...ause they provide a high strength to weight ratio and also a uniform ...d predictable rate of ablation. Several types of asbestos brake linings ...d clutch facings are made from asbestos cloth impregnated with ...itable compounds.

In addition to the organic type resins, inorganic compounds are also combined with asbestos cloth to provide high thermal insulating value, ...ght weight and exceptional resistance to physical abuse.

Metallic (wire-inserted) Asbestos Cloths are noted for their superior tensile strength and high resistance to heat and abrasion. These qualities make them virtually indispensable as a base in automotive and industrial friction materials, mechanical packings and gaskets, aircraft firewall and aerodynamic seals, and as jacketing over insulation on high temperature steam generators and turbines.

Aluminized Asbestos Cloth: By bonding an aluminum foil or film to a selected asbestos cloth, the properties of superior strength retention under prolonged heat exposure, high thermal reflectivity, and high resistance to frictional wear are obtained. As safety clothing and as blankets, hoods, curtains, etc., aluminized asbestos cloth forms an effective protective shield which reflects 90% of radiant heat and harmful infrared rays. The mirror bright aluminum surface, which is both attractive and durable, also adapts to such diversified uses as a maintenance-free insulation jacket for steam pipes, a flameproof wall and ceiling covering, and as a flexible air conductor for heating, cooling and ventilating equipment.

Asbestos Dryer Felts: This product is another example of the adaptability of asbestos textiles to an industry's specialized problems. Formerly, the dryer felts used on papermaking machines were generally made of all wool or all cotton yarns. These felts, under the deteriorating effect of heat, moisture and acidity, required frequent replacement. In the asbestos dryer felt, asbestos yarns are combined with cotton and certain synthetic yarns in such a way that the fabric is protected with a complete and un-

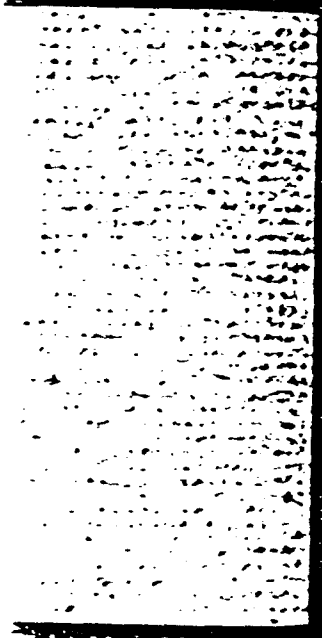

ATI Style Nos. 14P17
ATI Style Nos. 26P14
SOME TYPICAL WEAVES
ATI Style Nos. 36P10
ATI Style Nos. 40P10

roken surface of asbestos. Now used in many of the paper mills of the United States and Canada, this improved felt is giving from two to five times the serviceability of the ordinary felt, thereby effecting large savings in replacement costs. It also assures faster, more even drying with better finish and increased production rates.

Grades: Asbestos cloth is made in all standard ASTM grades as follows: Commercial, Underwriters', A, AA, AAA and AAAA. In general, the grades containing the higher percentages of asbestos provide greater thermal stability. (See Table K, page 33, for percentage of asbestos content in each grade, and Chart A, page 30, for strength retention properties).

Widths: Asbestos cloth is generally available in widths of 36", 40" and 60". Other widths are woven for special applications.

Weights: The style designation employed by the ATI uses both a numerical and alphabetical classification. In metallic cloths, the first two digits denote the weight per square yard expressed in ounces. The letter "M" indicates that the fabric is made with metallic or wire-inserted yarns, and the final digit or digits indicate the cut number of the yarns employed. In plain or non-metallic cloths, the meaning of each numerical designation

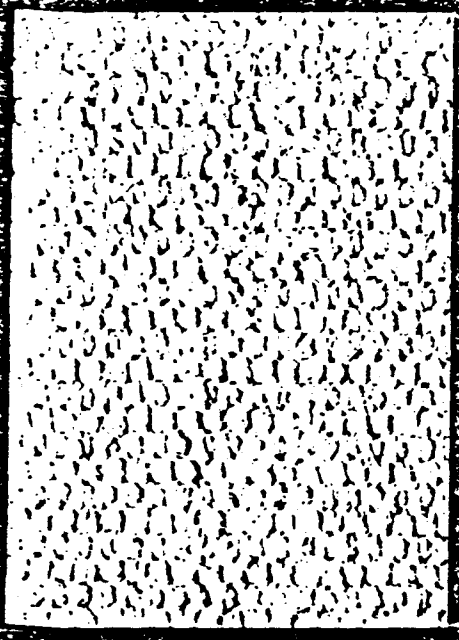


Style No. 26P-T4

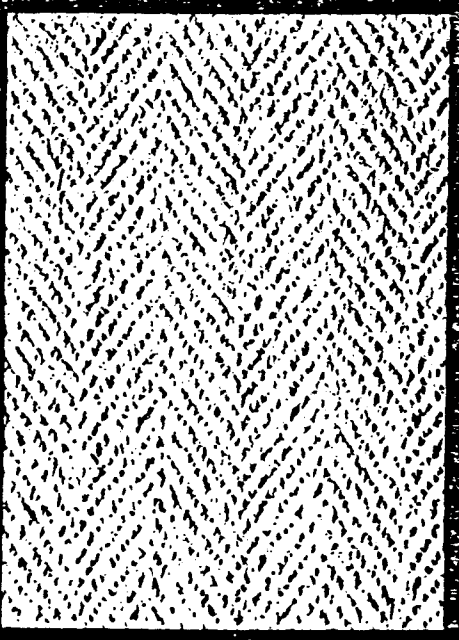
TICAL WEAVES OF ASBESTOS CLOTH



Style No. 40P10



ATI Style No. 84P10DC



ATI Style No. 19H120

is the same as that used in the metallic cloth classification. The alphabetical letter designates the weave used. The letter "P" stands for plain weave, "H" indicates a herringbone construction, and "T" denotes a twill. Tables N and P give weights and constructions of typical asbestos cloths.

Thicknesses: The thicknesses of single ply cloths range from approximately .015" to .100". Fabrics up to 1½" in thickness can be woven in multi-ply construction.

Tolerances: The tolerances for width, weight, thickness, yarn number (cut) and construction of asbestos cloth are in accordance with ASTM Specification D 1571. See page 71.

Standard Packages: Asbestos cloth is normally supplied in rolls of 50 and 100 linear yards. Other lengths can be ordered.

TABLE N—CONSTRUCTION OF TYPICAL METALLIC (WIRE-INSERTED) ASBESTOS CLOTHS

Weight Lbs. Sq. Yd. ±7%	ATI Style No.	Construction			
		Ends	Picks	Warp Yarn	Fill Yarn
2.00	32M8	14	14	811	811
2.00	32M12	19	9	1221	1211
2.15	35M10	18	8	1021	1011
2.25	36M10	18	8	1021	1011
2.30	37M12	18	8	1221	1221
2.44	39M10	18	9	1021	1021
2.50	40M10	17	8	1021	1021
2.50	40M10	12	7.5	1022	1022
2.50	40M12	18	8	1021	1221
2.75	44M8	14	10	822	821
2.75	44M9	17	8	921	921
2.75	44M10	18	9	1021	1021
2.75	44M10	14	8	1022	1022
2.80	45M12	18	9	1021	1221
2.90	46M10	19	10	1021	1021
3.00	48M8	16	10	822	821
3.00	48M10	18	9	1022	1021
3.25	52M10	20	10	1021	1021
3.45	55M8	16	7	822	822
3.45	55M10	18	9	1022	1022
3.50	56M10	18	9	1022	1022
4.00	64M10	22	10	1022	1022
4.25	68M10	16	8	1032	1032
6.25	100M12	45	15	1221	1221
7.00	112M10	35	12.5	1022	1022

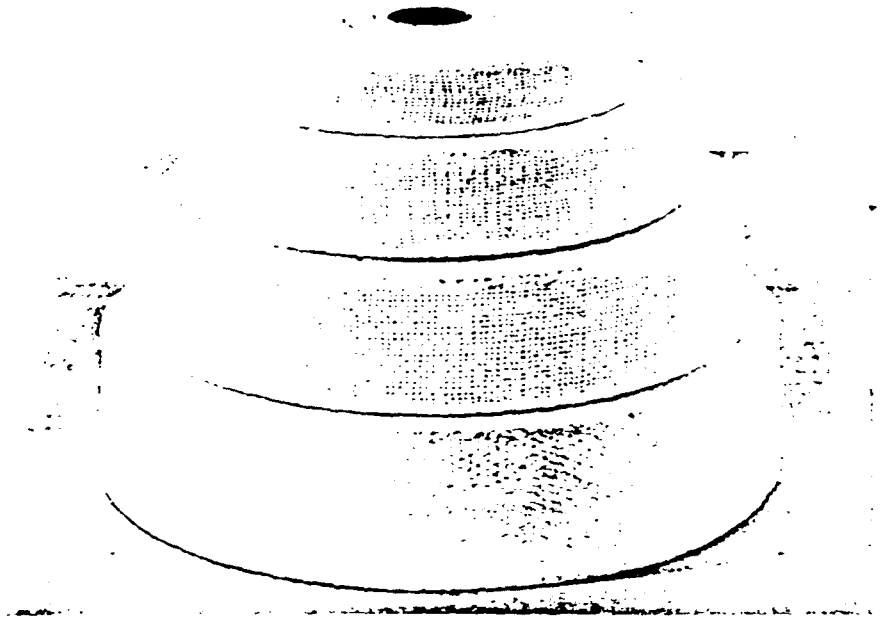
The Letter "M" in Style Number indicates Metallic Cloth.

TABLE P—WEIGHT AND CONSTRUCTION OF TYPICAL PLAIN (NON-METALLIC) ASBESTOS CLOTHS

Weight Lbs./Sq Yd ±7%	ATI Style No.	Construction				Tensile Strength*	
		Ends	Picks	Warp Yarn	Fill Yarn	Warp	Fill
0.50	8P26	20	14	2610	2610	30	25
0.65	10P24	21	22	2410	2410	40	45
0.70	11P20	21	17	2010	2010	40	30
0.75	12P18	21	17	1810	1810	40	30
0.90	14P17	21	19	1710	1710	55	50
0.95	15P26	15	14	2620	2620	45	40
1.05	17P10	20	15	1010	1710	65	40
1.05	17P24	16	15	2120	2420	55	50
1.10	18P10G	13	9	1010	1010	90	70
1.20	19H20	35	27	2010	2010	100	75
1.25	20P28	27	13	2820	2820	80	40
1.30	21P10	8	8	1020	1020	45	40
1.30	21P16	12	15	1620	1620	55	70
1.40	22P10G	18	9	1010	1010	125	70
1.40	22P16	19	10	1620	1620	80	40
1.40	22P22	21	12	2220	2220	75	35
1.45	23P18	17	14	1820	1820	55	50
1.50	24P10	9	9	1020	1020	50	45
1.65	26P10	10	10	1020	1020	55	50
1.65	26P12	13	13	1220	1220	65	60
1.65	26P14	14	14	1420	1420	75	70
1.75	28P16	24	10	1620	1620	115	50
1.80	29P10	16	10	1020	1010	90	30
1.80	29P14	20	10	1420	1420	95	40
1.95	31P12	10	11	1020	1230	55	100
2.00	32P12	18	9	1220	1220	90	40
2.10	34P10	16	9	1020	1020	90	45
2.25	36P8	16	6	820	820	100	40
2.25	36P10	18	9	1020	1020	125	50
2.27	37P10	18	10	1020	1120	135	55
2.35	38P12	20	12	1220	1220	105	55
2.50	40P10	20	10	1020	1020	135	55
2.50	40H14	28	14	1420	1420	160	70
3.00	48P10	18	9	1030	1020	180	55
3.00	48T12	30	10	1220	1220	170	50
3.30	53T12	36	12	1220	1220	180	55
3.70	59T12	40	14	1220	1220	—	—
4.20	67P10DC	30	14	1020	1020	—	—
4.75	76P10DC	37	16	1020	1020	—	—
5.25	84P10DC	40	15	1020	820	—	—
5.50	88P10DC	40	13.5	1020	1030	—	—

The letter "P" in Style Number indicates Plain Cloth. "H" indicates Herringbone Construction. "T" indicates Twill.

* Minimum average of 5 tests, grab method, according to ASTM Specification D 1682.



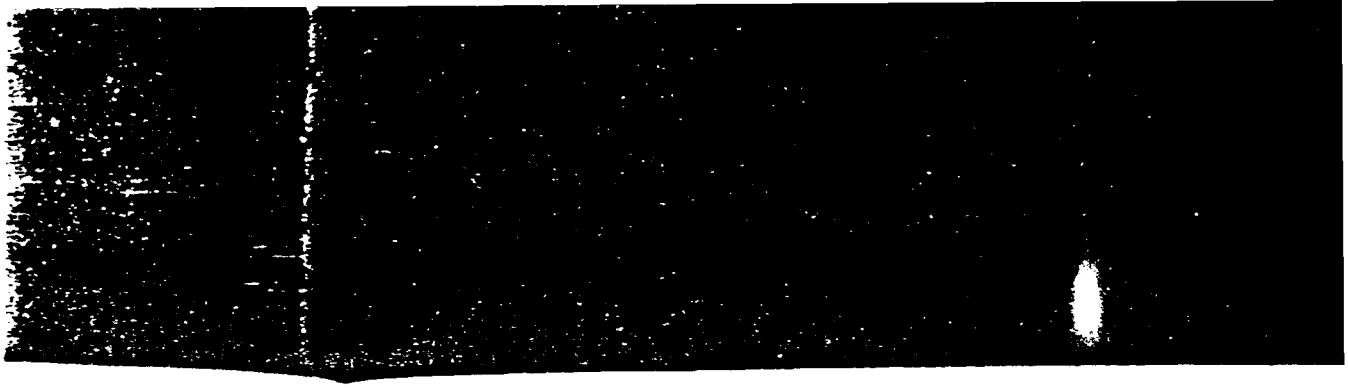
Asbestos Tape

ASBESTOS tape is a narrow woven fabric with selvage edges. It is made in five classes, the most commonly used being Class A, a plain or non-metallic tape, and Class B, a metallic or wire-inserted tape. The other three classes are described in ASTM Specification D 315, page 74.

Uses: Asbestos tapes are widely used in the electrical industry as an insulation and have numerous other applications where an incombustible woven tape of high tensile strength and thermal stability is required.

Plain (non-metallic) Tapes of thin dimension are designed primarily for electrical insulating purposes such as motor windings, where there is need for a heat conductive, thermally stable insulation capable of absorbing a high percentage of insulating varnishes and treatments. The impregnated tape forms a moisture barrier essential to efficient motor operation.

Heavier plain tapes are widely used as a durable flameproof wrapping for lead sheathed cables, as an insulation for pipe hangers, as safety protection for covering hot piping, as stress-relieving pads in welding operations, and as a component of packings and gaskets. When specially treated, these tapes provide such advantages as arc proofing and resistance to oil, water and corrosion for electrical cables; they can also be produced to withstand the destructive action of thermo-mechanical forces for other applications.



Metallic (wire-inserted) Tapes are designed for service requiring higher tensile strength or a high coefficient of friction or where extreme abrasive conditions are present. They are used as the major component in woven brake linings and clutch facings and as oil burner wicking. These tapes are woven with special alloy wires for applications where excessively high temperatures are encountered.

The thermal stability of asbestos tape adapts it particularly for use as a conveyor belting for carrying hot materials. Both plain and metallic tapes are made for this purpose. Some are woven with the top ply of plain yarn and the bottom ply of metallic yarn to resist stretch and may be specially treated to increase resistance to abrasion.

Grades: Asbestos tapes for electrical purposes are made in Underwriters' grade. Tapes for other uses are available in all standard ASTM grades from Commercial through AAAA. In general, the tapes with higher asbestos content are used where high temperature conditions are encountered. (See Table K, page 33, for percentage of asbestos content in each grade.)

Thicknesses, Widths: Standard thicknesses of thinner plain tapes range from .010" up to .030". Greater thicknesses can also be furnished. Heavier plain tapes are made in thicknesses up to $\frac{1}{4}$". Metallic tapes are woven in thicknesses of $\frac{1}{16}$" and heavier. Standard widths of asbestos tape range from $\frac{1}{2}$" to 6". Tolerances conform to ASTM specifications.[6]

Weights: The weight of asbestos tape varies from fractions of a pound to more than 100 pounds per 100 feet, depending on size. Tables Q and R show the approximate number of pounds per 100 feet and the approximate footages per pound of tapes of standard thicknesses and widths. Tapes of weights other than those shown can also be woven.

Electrical Insulation Classification: Asbestos tape as made for the electrical industry is furnished in three types, classified on the basis of magnetic rating determinations[7] which serve to identify performance limits.

Type II (Magnetic Rating 0.75 Maximum) is intended only for special applications where the asbestos is of primary importance as electrical insulation used on magnet wire and when used primarily as a dielectric.

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[6] For permissible variations in thickness, width, weight and construction, and other data about asbestos tape not given above, see ASTM Specification D 315, page 74.

[7] See ASTM Specifications D 2100, page 78, and D 1118, page 81.

Type IV (Magnetic Rating 2.00 Maximum) is intended for use where the asbestos is of secondary importance as electrical insulation and where it is applied in combination with other materials of comparably higher dielectric strength, as in the construction of heat and flame resistant electrical insulating walls over unit conductors of electric cables.

Type VI (Magnetic Rating 4.00 Maximum) is intended for use where the asbestos is of minor importance as a dielectric, as in the construction of filler or heat and flame resistant walls of electric cables or when used as a lining for control enclosures subject to exposure to electric arcs.

Standard Packages: Asbestos tapes for electrical insulation (plain tapes up to and including .030" thick) are generally furnished in 36 yard rolls wound on bushings. Industrial tapes of $\frac{1}{32}$" and greater thickness are furnished in 100 and 150 foot rolls.

TABLE Q—METALLIC (WIRE-INSERTED) WOVEN ASBESTOS TAPE
Asbestos Textile Institute Standards*

Thickness Inches	Width Inches	Approx. Ft. Per Lb.	Approx. Lbs. Per 100 Ft.	Thickness Inches	Width Inches	Approx. Ft. Per Lb.	Approx. Lbs. Per 100 Ft.
1/16	½	64.1	1.56	⅛	5½	2.5	39.9
	¾	42.7	2.34		6	2.3	43.4
	1	32.0	3.12		3	4.4	22.6
	1¼	23.9	4.18		3½	3.8	26.1
	1½	19.0	5.25		4	3.4	29.5
	2	15.1	6.62		4½	3.0	33.0
	2½	12.1	8.26		5	2.7	36.4
	3	10.0	9.93				
	3½	8.61	11.61	¼	1	7.1	14.1
	4	7.55	13.24		1¼	5.7	17.6
	4½	6.71	14.90		1½	4.7	21.2
	5	6.04	16.55		2	3.5	28.3
	5½	5.49	18.21		2½	2.8	35.4
	6	5.03	19.87		3	2.3	43.6
					3½	2.0	50.0
⅛	¾	16.9	5.9		4	1.8	56.3
	1	12.7	7.9		4½	1.6	62.6
	1¼	10.9	9.1		5	1.4	70.4
	1½	9.6	10.4		5½	1.3	77.4
	2	6.6	15.2		6	1.1	83.7
	2½	5.6	17.9				

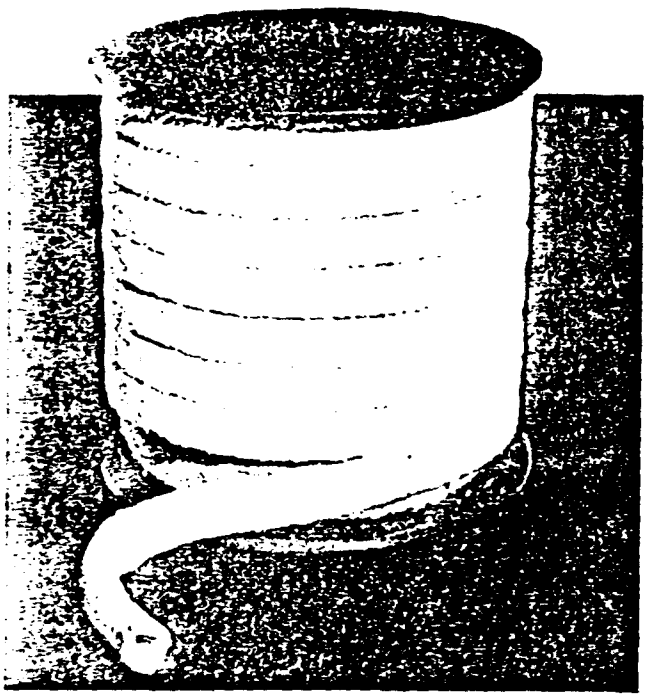
* Tapes can also be supplied in greater widths and thicknesses.

TABLE R—PLAIN (NON-METALLIC) WOVEN ASBESTOS TAPE

Asbestos Textile Institute Standards*

Thickness Inches	Width Inches	Approx. Ft. Per Lb.	Approx. Lbs. Per 100 Ft.
.010	½	420.0	0.24
	¾	291.0	0.34
	1	222.0	0.45
	1¼	183.0	0.55
	1½	155.4	0.64
	1¾	133.8	0.75
	2	117.3	0.85
.015	½	276.0	0.36
	¾	198.9	0.50
	1	153.6	0.65
	1¼	126.0	0.79
	1½	108.0	0.93
	1¾	99.0	1.00
	2	84.0	1.18
.020	½	224.4	0.45
	¾	159.9	0.63
	1	123.3	0.81
	1¼	100.5	0.99
	1½	84.9	1.18
	1¾	73.5	1.36
	2	64.8	1.54
.025	½	168.9	0.59
	¾	119.4	0.84
	1	92.4	1.08
	1¼	75.0	1.33
	1½	63.0	1.58
	1¾	54.9	1.82
	2	48.6	2.06
	2½	37.6	2.66
	3	31.5	3.16
.030	½	134.1	0.75
	¾	90.9	1.10
	1	68.7	1.46
	1¼	56.4	1.77
	1½	47.7	2.10
	1¾	40.8	2.45
	2	36.0	2.78
	2½	28.2	3.54
	3	23.8	4.20
1/32	½	125.0	.80
	¾	84.7	1.18
	1	60.2	1.66
	1¼	50.0	2.00
1/32	1½	41.7	2.40
	2	32.2	3.10
	2½	26.3	3.80
	3	22.2	4.50
1/16	½	81.3	1.23
	¾	50.0	2.00
	1	40.5	2.47
	1¼	31.5	3.17
	1½	26.3	3.80
1/16	2	19.4	5.16
	2½	15.2	6.60
	3	13.2	7.60
	3½	11.2	8.9
	4	9.9	10.1
	4½	8.8	11.3
	5	7.9	12.7
	5½	7.1	14.0
	6	6.6	15.2
⅛	¾	21.3	4.7
	1	15.9	6.3
	1¼	13.6	7.3
	11½	12.0	8.3
	2	8.2	12.2
	2½	7.0	14.3
	3	5.5	18.1
	3½	4.8	20.8
	4	4.2	23.6
	4½	3.8	26.4
	5	3.4	29.1
	5½	3.1	32.0
	6	2.9	34.8
¼	1	8.3	12.0
	1¼	6.7	15.0
	1½	5.6	18.0
	2	4.2	24.0
	2½	3.3	30.0
	3	2.8	36.0
	3½	2.4	42.0
	4	2.1	48.0
	4½	1.9	54.0
	5	1.7	60.0
	5½	1.5	66.0
	6	1.4	72.0

* Tapes can also be supplied in greater widths and thicknesses.



Asbestos Tubing

ASBESTOS tubing, sometimes called tubular sleeving, is made from asbestos yarns, either braided or woven. The braided style is supplied in many diameters and textures and in several wall thicknesses to meet a variety of service conditions. It is furnished untreated or treated, as may be required. The woven style can be manufactured in various constructions and is usually made to specification.

Uses: Braided asbestos tubings are widely used as a sleeving for electrical appliance leads, cables and other conductors to provide fire protection and resistance to mechanical abrasion. They are also extensively used for covering the lead wires of thermocouples and in the glass industry they protect the hot glassware from injury by serving as a covering for pincers and tongs.

An important practical advantage of braided tubing is the ease with which it can be fitted over the surface to be covered. A braided tubing will slide readily over a rod, wire or cable of the same outside diameter as the inside diameter of the tubing, and if necessary its flexibility will allow it to be expanded or contracted to fit slightly larger or smaller diameters.

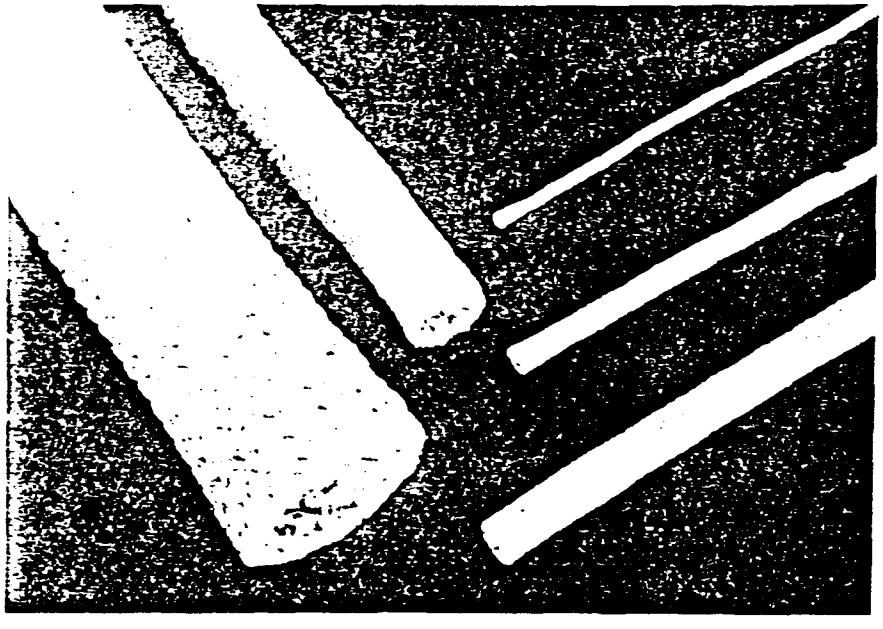
...woven style of asbestos tubing is particularly adapted for the insula-...on of bus bars. Woven tubing of large diameters is sometimes formed ...to the dust bags used in pneumatic systems for filtering hot waste gases ...hich constitute a fire and dust hazard.[8]

...rades: Asbestos tubing is made in all standard ASTM grades – Com-...ercial, Underwriters', A, AA, AAA and AAAA. (See Table K, page 33, ...r percentage of asbestos content in each grade.)

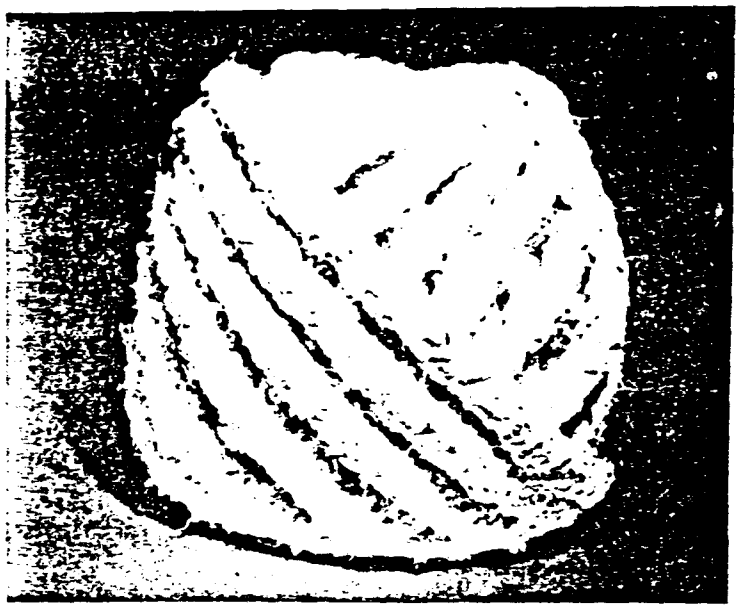
...izes: Braided tubings are produced with inside diameters ranging from ..." up to several inches. Wall thicknesses range from less than $\frac{1}{32}$" to approximately $\frac{1}{8}$".

Woven tubings are made in diameters from less than 1" up to 22½".

Standard Packages: Braided tubing is packaged on spools in quantities ranging from 5 lbs. for thin walled tubing to 50 lbs. for heavy walled ...bing. Woven tubing is sold in rolls, or cut to specified lengths.



[8] See also "Asbestos Cloth," page 42.



Asbestos Wick

Asbestos wick is a soft pliable strand of asbestos formed by loosely twisting together several strands of roving, slubbing or felted asbestos. It is supplied either with or without cotton yarn reinforcement.

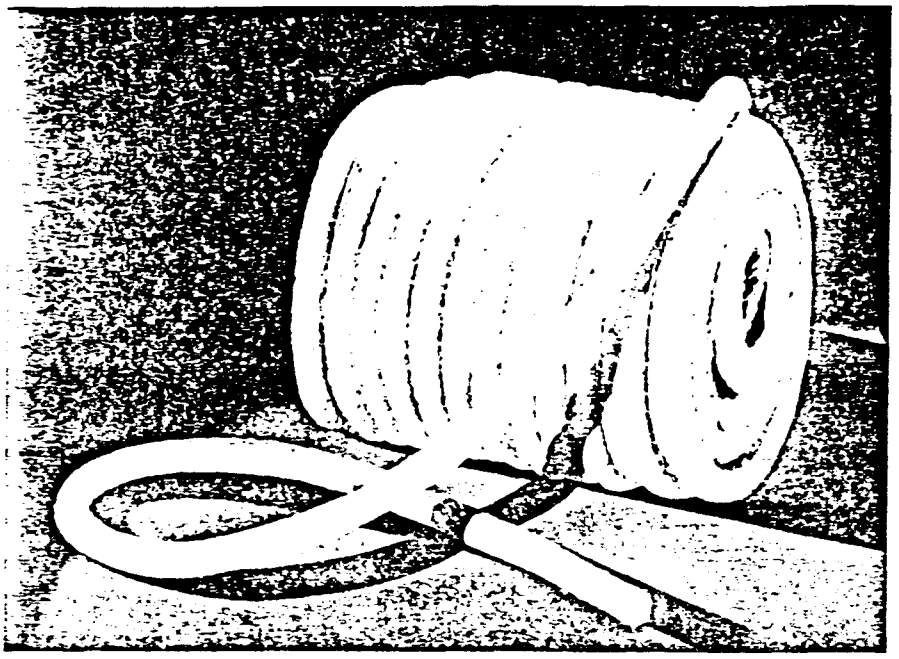
Uses: Furnished in convenient ready-to-use form, asbestos wick is a general utility product of many and varied applications. The power plant engineer keeps it handy as an emergency packing. The plumber finds it useful for packing steam and hot water valves. The roofer depends on it as a weather seal for corrugated roofing. Maintenance workers use it for caulking retorts, for sealing ovens and furnace doors and similar jobs.

Specially designed asbestos wick is used to wipe excess metal from wire in the process of tinning and galvanizing and as a core for high temperature packings.

Grades: The standard grade of asbestos wick is Commercial but other grades are supplied on order by most manufacturers. (See Table K, page 33, for percentage of asbestos content in each grade.)

Sizes: The ¼" diameter is standard for most purposes but other diameters (usually from ⅛" or 3/16" up to 7/32" or ½") are also furnished.

Standard Packages: Asbestos wick is sold in handy ¼, ½ and 1 pound balls and in larger quantities (usually 10, 25 and 50 pounds) wound on spools or reels.



Asbestos Rope

THIS product is produced in two styles: twisted and braided.

Twisted asbestos rope is made by twisting tightly together two or more strands of asbestos wick. In the heavier ropes, a binder is generally used to hold the twist.

Braided asbestos rope is made in three constructions: (1) by braiding one or more jackets of asbestos yarn over a core of asbestos rope or wick; (2) by braiding asbestos yarn braid over braid to form a finished product of either square or round cross-section; and (3) by plaiting asbestos yarn into square cross-section. The braid over braid rope is firmer and stronger; the plaited rope is softer and conforms more readily when compressed.

Uses: Asbestos rope, a companion product to asbestos wick, is used where a thicker material than wick is desired. The twisted style is widely used as a seal between furnace doors and brickwork, as a filling for expansion joints in plastic walls of boiler settings, for covering diesel engine exhaust lines, for packing boiler expansion and gas generator doors, as a gasketing material for manhole covers and as a core for high temperature packing.

The braided style is used as a groove packing for inspection doors, as

filling for expansion joints in furnace brickwork, as a gasket for sealing doors of water gas generators and similar services.

Grades: Asbestos rope is furnished in Commercial grade for most general uses and in Underwriters', AA, AAA and AAAA grades to meet particular service requirements. The grades with higher asbestos content are used for high temperature applications. (See Table K, page 33, for percentage of asbestos content in each grade.)

Sizes: Asbestos rope is made in a wide range of diameters, usually from $\frac{1}{4}$" up to $1\frac{1}{2}$" or 2".

Standard Packages: Asbestos rope is generally sold in 10, 25 and 50 pound units wound in coils or on reels and packed in individual cartons.

TABLE S—APPROXIMATE WEIGHTS AND FOOTAGES OF ASBESTOS ROPE

Nominal Diameter Inches	Approx. Lbs. per 100 Ft.	Approx. Ft. per Lb.
¼	2.5	42.00
⅜	5.0	20.00
½	8.5	11.75
⅝	12.5	8.00
¾	16.5	6.10
⅞	25.0	4.00
1	31.0	3.00
1¼	40.0	2.50
1½	56.0	1.80

a gasket for sealing

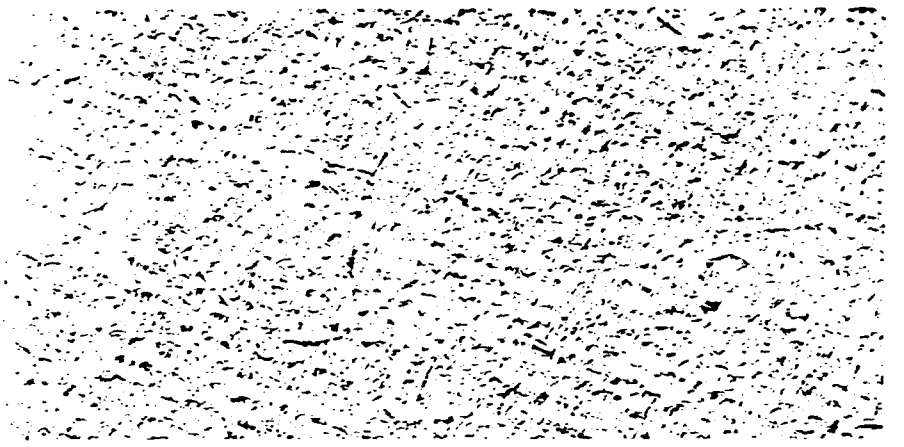
ıde for most general
·s to meet particular
os content are used
e 33, for percentage

ıeters, usually from

in 10, 25 and 50
individual cartons.

OOTAGES

PPROX. FT. PER LB.
42.00
20.00
11.75
8.00
6.10
4.00
3.00
2.50
1.80



Non-Woven Asbestos Felts

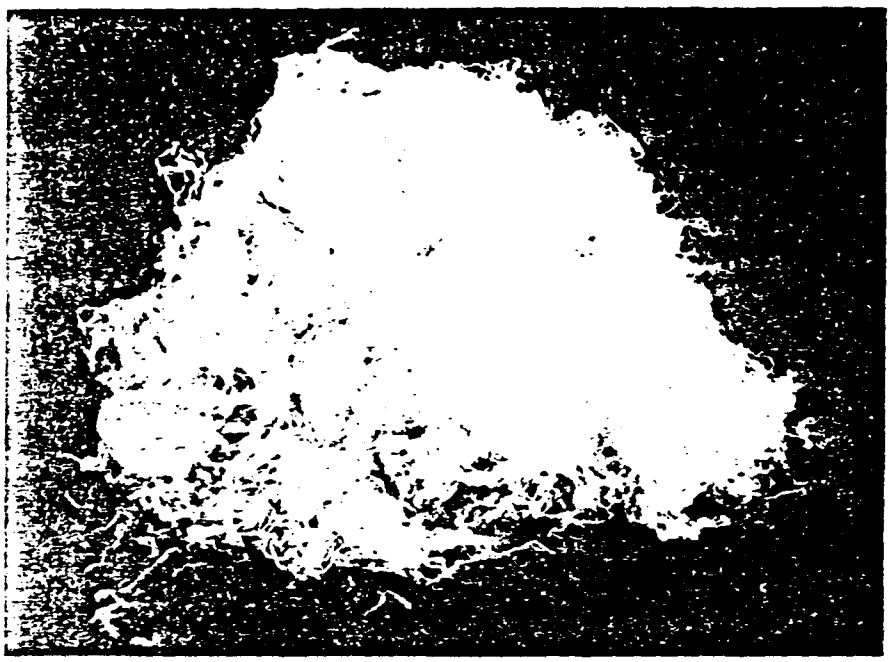
NON-WOVEN asbestos felts are produced in sheet formation by carding or other fiber orienting processes. Special binders may be added to provide processing strength. They are available both with and without glass cloth reinforcement and are produced as sheets, tapes and rolls.

Uses: These non-woven materials extend the useful range of asbestos textiles by providing a strong thin felt readily saturable with resins. They are extensively used as basic reinforcements in both high and low pressure plastics. They also provide the basic reinforcement in impregnated asbestos tapes used as primary and secondary insulation in high temperature resistant wire and cable.

Exhibiting a strength to weight ratio unapproached by most other available materials, resinated non-woven asbestos felts are finding important applications as components of rockets and missiles. Other properties which adapt them particularly to the requirements of this service are: uniform ablation, low thermal conductivity, low thermal diffusivity and excellent dimensional stability. Resinated asbestos felts retain a higher percentage of physical properties after exposure to extremely elevated temperatures than other inorganic reinforcements or fillers. (For test data on their performance at elevated temperatures, see page 32.)

Grades: Non-woven asbestos felts are made in standard ASTM grades, from Commercial through grade AAAA. (See Table K, page 33.)

Thicknesses, Widths: Standard thicknesses range from .010″ to 3/16″. Available in widths from ½″ to 54″.



Carded Asbestos Fiber

CARDED asbestos fiber is 100% asbestos which has been fiberized by passing the crude through the several operations of the fiberizing process and by screening and carding. It is furnished in various qualities which are determined by the fiber length and type of crude asbestos used and by the operations necessary to produce the carded fiber.

Uses: One of the major uses of carded asbestos fibers is for the clarification of such liquids as beer, wine, oils and chemicals. The mass of tiny fibers forms a filter medium of extremely close texture which captures the undesirable suspended impurities when the liquid is allowed to pass through it. Because of the fibrous nature of asbestos, it may be opened up in processing to any extent desired. Consequently, carded asbestos fibers can be furnished in many degrees of fineness to provide exactly the right screening for the liquid to be filtered.

This product is also widely used as a pad for wiping excess metal from wire during manufacture and as stuffing box packing.

Standard Packages: Carded asbestos fiber is packaged in 10, 25 and 50 pound cartons and in boxes containing one pound and smaller amounts.

ASTM Specifications for Asbestos Textiles

Pages 60 through 96 contain the American Society for Testing and Materials specifications relating to asbestos textiles, reproduced here with the permission of the Society. These were in effect at the time this edition of the Handbook of Asbestos Textiles was printed. However, since ASTM specifications are subject to continuous study and review, the reader should consult the Society's current "ASTM Standards on Textile Materials" for possible subsequent revisions. See index for subject and individual specification reference.

NOTE: ASTM Specifications and Methods of Test are subject to continual revision. Consult the Society's current "ASTM Standards on Textile Materials" for possible changes in this specification.

Standard Specifications for and Methods of Testing

ASBESTOS LAP[1]

ASTM Designation: D 1061 – 58

ADOPTED, 1954; LAST REVISED, 1958

This Standard of the American Society for Testing and Materials is issued under the fixed designation D 1061; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval.

NOTE.—Editorial changes in Sections 4 and 11 were made in October, 1959. Sections 2, 4, and 9 were revised and Section 11 on Magnetic Rating was deleted editorially in June, 1962.

Scope

1. These specifications and methods of test apply to asbestos lap, a felted asbestos product.

Definition

2. *Asbestos Lap* is an asbestos textile product which is identified by (*1*) Style, (*2*) Type, and (*3*) Weight.

(*a*) *Style.*—The style of asbestos lap refers to the physical construction and two distinctly different styles are normally available:

Style I.—A ribbon-like formation of felted asbestos fiber.

Style II.—A parallel assemblage of Style I lap.

(*b*) *Type.*—The type of asbestos lap refers to the electrical properties of the lap as given in the Specification for Asbestos Textiles Used for Electrical Insulating Purposes (ASTM Designation: D 2100).[2]

(*c*) *Weight.*—The weight of asbestos lap is normally expressed in the number of grains per linear yard.

Grades

3. (*a*) The grade of asbestos lap shall be determined by the percentage of asbestos by weight, and shall conform to the following requirements:

Grade	Asbestos Content, per cent
Underwriters' Grade	80 to 85, excl
Grade A	85 to 90, excl
Grade AA	90 to 95, excl
Grade AAA	95 to 99, excl

Electrical Properties

4. Asbestos lap used for electrical insulation shall conform to the Specifica-

[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the ASTM Committee D-13 on Textile Materials, and are the direct responsibility of Subcommittee A-4 on Asbestos and Its Textile Products.

[2] Appears in this publication.

tion for Asbestos Textiles Used for Electrical Insulating Purposes (ASTM Designation: D 2100).[2]

Weight

5. Weight of asbestos lap shall conform to the following requirements as to permissible variations:

	Permissible Variations in Average Grains per Linear Yard of Five Test Specimens, per cent	Permissible Variations in Grains per Linear Yard of Single Test Specimen, per cent
Style I	8	15
Style II	5	10

METHODS OF TESTING

Sampling

6. (*a*) Each shipment shall be divided into lots of from 800 to 1000 lb. From each lot or fraction thereof, five sample packages shall be taken at random and the tests prescribed shall be made on specimens removed from each package selected.

(*b*) If tests from any lot fail to fall within the specified limits, two additional sets of five sample packages shall be taken from other parts of the lot and tested as before. Acceptance shall be on the basis of these two sets of five sample packages being within the required limits.

(*c*) Optional with the purchaser, if the values determined in accordance with Paragraph (*b*) fail to fall within the specified limits, the lot shall be subdivided into units of approximately 200 lb. These shall be sampled and tested for conformance in accordance with Paragraph (*a*) and (*b*).

Test Conditions

7. All test specimens shall be brought to standard condition in accordance with Section 8 prior to testing and all tests shall be conducted under standard conditions.

Standard Condition

8. Standard condition of asbestos lap shall be that reached by the lap when in moisture equilibrium with a standard atmosphere having a relative humidity of 50 per cent at 21 C (70 F). A tolerance of ±2 per cent is permitted in relative humidity and ±1.1 C (2 F) in temperature (Note).

NOTE.—For purposes of tests, it is recognized that specimens reach moisture equilibrium after exposure for at least 4 hr unless otherwise specified, under above conditions.

Asbestos Content

9. The asbestos content shall be determined in accordance with the Method of Test for Asbestos Content of Asbestos Textile Materials (ASTM Designation D 1918).[2]

Weight

10. From each of five packages selected in accordance with Section 6, a 1-yd test specimen shall be taken. Care shall be taken that the specimen is not scuffed or torn, and for this reason the outer wrap of the lap shall be removed before taking the specimen. Each specimen shall be weighed to the nearest grain, and the average weight of the five specimens calculated.

NOTE: ASTM Specifications and Methods of Test are subject to continual revision. Consult the Society's current "ASTM Standards on Textile Materials" for possible changes in this specification.

Standard Specifications and Methods of Test for

ASBESTOS ROVING[1]

ASTM Designation: D 375 – 59

ADOPTED, 1936; LAST REVISED, 1959

This Standard of the American Society for Testing and Materials is issued under the fixed designation D 375; the final number indicates the year of original adoption as standard or, in the case of revision, the year of last revision.

NOTE.—Editorial changes in Sections 2, 8, 9, and 10 were made June, 1960; also the Notes were numbered. Editorial changes throughout the method were made in June, 1962.

Scope

1. These specifications and methods of test apply to asbestos roving, used mostly as the main component of heat-resistant electrical insulation for various types of wire and cable. Two types are covered as defined in Section 2(*a*) and (*b*).

Definitions

2. (*a*) *Asbestos Roving.*—An assemblage of carded asbestos, with or without other fibers, rubbed into a single strand without twist.

(*b*) *Reinforced Asbestos Roving.*—Asbestos roving containing a core of other fibers.

(*c*) *Standard Condition.*— Standard condition of asbestos roving shall be that reached by the roving when in moisture equilibrium with a standard atmosphere having a relative humidity of 50 per cent at 70 F (21 C). A tolerance of ±2 per cent is permitted in relative humidity and ±2 F (1.1 C) in temperature.

NOTE.—For purpose of tests, it is recognized that specimens reach moisture equilibrium after exposure to moving air for at least 4 hr, unless otherwise specified, under the above conditions.

(*d*) *Number (Cut).*—A number hyphenated with the word "cut" indicates the number of 100-yd units in 1 lb of a standard asbestos roving, and designates the cut-number of that roving.

Number (Cut)

3. (*a*) The standard number of asbestos roving is designated as "cut." The yards per pound of the standard cuts shall conform to the requirements as prescribed in Table I.

NOTE 1.—The tolerances on special numbers such as 5½-cut, 6½-cut, etc. shall be equal to those of the standard numbers.

(*b*) The cut of reinforced asbestos roving shall be determined without removing the reinforcing core yarn.

[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the ASTM Committee D-13 on Textile Materials, and are the direct responsibility of Subcommittee A-4 on Asbestos and Its Textile Products.

Grades

4. (*a*) The grade of asbestos roving shall be determined by the percentage of asbestos by weight, and shall conform to the following requirements:

Grade	Asbestos Content, per cent
Underwriters' grade	80 to 85, excl
Grade A	85 to 90, excl
Grade AA	90 to 95, excl
Grade AAA	95 to 99, excl

TABLE I.—REQUIREMENTS FOR YARDS PER POUND OF STANDARD ASBESTOS ROVING.

Cut Number	Nominal Yards per Pound	Permissible Variations in Average Yards per Pound	Permissible Variations in Yards per Pound of Single 30 yd Skein
5-cut	500	460 to 540	425 to 575
6-cut	600	552 to 648	510 to 690
7-cut	700	644 to 756	595 to 805
8-cut	800	736 to 864	680 to 920
9-cut	900	828 to 972	765 to 1035
10-cut	1000	920 to 1080	850 to 1150
12-cut	1200	1104 to 1296	1020 to 1380
14-cut	1400	1288 to 1512	1190 to 1610
16-cut	1600	1472 to 1728	1360 to 1840
18-cut	1800	1656 to 1944	1530 to 2070
20-cut	2000	1840 to 2160	1700 to 2300
22-cut	2200	2024 to 2376	1870 to 2530
24-cut	2400	2208 to 2592	2040 to 2760
26-cut	2600	2392 to 2808	2210 to 2990
28-cut	2800	2576 to 3024	2380 to 3220
30-cut	3000	2760 to 3240	2550 to 3450
35-cut	3500	3220 to 3780	2975 to 4025
40-cut	4000	3680 to 4320	3400 to 4600
45-cut	4500	4140 to 4860	3825 to 5175
50-cut	5000	4600 to 5400	4250 to 5750

NOTE 2.—The 16- and 18-cut rovings are available only in the Underwriters' grade: all other cuts are available in all four grades.

(*b*) The asbestos content of reinforced asbestos roving shall be determined without removing the reinforcing core yarn.

Electrical Properties

5. Asbestos roving used for electrical insulation shall conform to the Specification for Asbestos Textiles Used for Electrical Insulating Purposes (ASTM Designation: D 2100).[2]

[2] Appears in this publication.

METHODS OF TESTING

Sampling

6. (*a*) Each shipment shall be divided into lots of from 800 to 1000 lb. From each lot or fraction thereof, five sample cones shall be taken at random and the tests prescribed shall be made on specimens removed from each package selected.

(*b*) If tests from any lot fail to fall within the specified limits, two additional sets of five sample cones shall be taken from other parts of the lot and tested as before. Acceptance shall be on the basis of these two sets of five sample cones being within the required limits.

(*c*) Optional with the purchaser, if the values determined in accordance with Paragraph (*b*) fail to fall within the specified limits, the lot shall be subdivided into units of approximately 200 lb. These shall be sampled and tested for conformance in accordance with Paragraphs (*a*) and (*b*).

Test Conditions

7. All test specimens shall be brought to a standard condition in accordance with Section 2 (*c*) prior to testing and all tests shall be made under the standard condition.

Number (Cut)

8. (*a*) *Number of Tests.*—Make ten determinations of the number of yards per pound on each set of five packages selected.

(*b*) *Procedure.*—Group the packages on the floor and draw five strands from them slowly, looping over a support to assemble 20 strands, which shall be cut into a 1-yd length while suspended. Weigh the 20 yd to the nearest 0.1 grain and calculate the number of yards per pound from the following formula:

(D 375)

asbestos content in
Method of Test for
of Asbestos Textile
esignation: D 1918).[2]

APPROVED AS
AMERICAN STANDARD L14.18-1961
BY AMERICAN STANDARDS ASSOCIATI
UDC 677.31:620.1

NOTE: This Specification is scheduled for revision by the ASTM in 1967 to conform with the class designations for Asbestos Yarn as shown on pages 38 and 39 of this edition of the Handbook.

Standard Specifications and Methods of Test for

ASBESTOS YARNS[1]

ASTM Designation: D 299 - 60

ADOPTED 1954; REVISED, 1960.[2]

This Standard of the American Society for Testing and Materials is issued under the fixed designation D 299; the final number indicates the year of original adoption as standard or, in the case of revision, the year of last revision.

NOTE.—Section 8 was added and Sections 2, 11, and 14 were revised editorially in June, 1962.

Scope

1. These specifications define asbestos yarn, prescribe the methods of testing, and stipulate tolerances.

Definitions

2. (*a*) *Asbestos Yarn.*—A twisted assemblage of: (*1*) asbestos fiber, (*2*) asbestos and other fibers, (*3*) asbestos and other fibers and wire, or (*4*) asbestos and other fibers with an insert of cotton or other yarn reinforcement.

(*b*) *Plain Asbestos Yarn.*—Plain
bestos yarn consists of: (*1*) asbes
fiber, or (*2*) asbestos and other fib

(*c*) *Metallic Asbestos Yarn.*—Meta
asbestos yarn consists of plain asb
tos yarn or roving twisted with br
copper, or other fine wire. It is a
termed "wire-inserted yarn."

(*d*) *Reinforced Asbestos Yarn.*—Pl
asbestos yarn or roving twisted w
an insert of yarn made of other fibers

(*e*) *Standard Condition.*—Stand
condition of asbestos yarn shall be t
reached by the yarn when in moist
equilibrium with a standard atmosph
having a relative humidity of 50 per c
at 70 F (21 C). A tolerance of ±2
cent is permitted in relative humid
and ±2 F (1.1 C) in temperature.

NOTE.—For purpose of tests, it is recogni
that specimens reach moisture equilibrium a
exposure for at least 4 hr, unless otherwise sp
fied, under the above conditions.

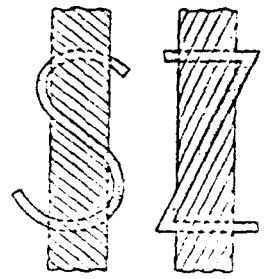
(*f*) *Twist, Direction of.*—A yarn ha

[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the ASTM Committee D-13 on Textile Materials, and are the direct responsibility of Subcommittee A-4 on Asbestos and Its Textile Products.

[2] Prior to their present adoption as standard, these specifications were published as tentative from 1928 to 1929. They were adopted in 1929, published as standard from 1929 to 1941, being revised in 1933, 1936, and 1937, but withdrawn and replaced in 1941 by Tentative Specifications D 299 - 40 T which were published as tentative from 1940 to 1942. They were again adopted in 1942 and published as standard from 1942 to 1948. They were reverted to tentative in 1948, and were published as tentative from 1948 to 1954, being revised in 1949, 1950, 1951, and 1952.

twist if, when held in a vertical position, the spirals around its central axis conform in direction of slope to the central portion of the letter "S," and Z twist if the spirals conform in direction of slope with the central portion of the letter "Z."

NOTE.—This definition applies to the twist in single yarns, the ply twist in plied yarns, and the cable or hawser twist in cords.



S Twist Z Twist

(*g*) *Cut (Asbestos).*—A term derived by cutting (dividing) 7000 grains into linear mass units by the grain weight of 100 yd of a single yarn. The number of such units expresses the number of the cut and, when multiplied by 100, indicates the nominal yards per pound.

Example.—If five 30-yd skeins of single yarn, or 150 yd, weigh 637.5 grains, then 100 yd weigh 425 grains.

$\frac{7000}{425} = 16.47$, or 16.47-cut, which is 16-cut on the light side; and $16 \times 100 = 1600$ nominal yd per lb.

(*h*) *Ply.*—Ply is the number of strands of single asbestos yarn twisted together to form a heavier yarn. Ply is a term used principally in combination with a number to designate the strands of single yarn twisted together, as 2-ply, 3-ply, etc.

(*i*) *Number (Cut).*—A *number* hyphenated with the word *cut* indicates the number of 100-yd units in 1 lb of a standard asbestos yarn, and designates the cut-number of that yarn.

(*j*) *Yarn Construction.*—Based on cut as defined in Paragraph (*g*), asbestos yarns are designated in the asbestos textile industry by numbers which indicate the cut-number, the number of plies, and whether the yarn is plain or metallic. All yarns comprising 5-cut to 9-cut, inclusive, have 3-digit construction numbers; yarns comprising 10-cut to 50-cut, inclusive, have 4-digit construction numbers. Digits are significant as follows:

The last digit, if zero, indicates plain yarn; if the last digit is 1, 2, or 3, the number of strands of wire twisted with the asbestos is designated.

The next to last digit designates the plies.

The remaining digits (1 or 2) designate the cut-number.

Examples:

No. 931 yarn..... 9-cut, 3-ply–1 wire yarn
No. 1010 yarn..... 10-cut, single, plain yarn
No. 1420 yarn..... 14-cut, 2-ply, plain yarn

TABLE I.—REQUIREMENTS YARDS PER POUND OF STAND SINGLE ASBESTOS YARNS.

Cut Number	Nominal Yards per Pound	Permissible Variations in Average Yards per Pound	Perm... Varia... Yar... Pound ... 30-yd ...
5-cut.....	500	460 to 540	425 t...
6-cut.....	600	552 to 648	510 t...
7-cut.....	700	644 to 756	595 t...
8-cut.....	800	736 to 864	680 t...
9-cut.....	900	828 to 972	765 t...
10-cut.....	1000	920 to 1080	850 t...
12-cut.....	1200	1104 to 1296	1020 t...
14-cut.....	1400	1288 to 1512	1190 t...
16-cut.....	1600	1472 to 1728	1360 t...
18-cut.....	1800	1656 to 1944	1530 t...
20-cut.....	2000	1840 to 2160	1700 t...
22-cut.....	2200	2024 to 2376	1870 t...
24-cut.....	2400	2208 to 2592	2040 t...
26-cut.....	2600	2392 to 2808	2210 t...
28-cut.....	2800	2576 to 3024	2380 t...
30-cut.....	3000	2760 to 3240	2550 t...
35-cut.....	3500	3220 to 3780	2975 t...
40-cut.....	4000	3680 to 4320	3400 t...
45-cut.....	4500	4140 to 4860	3825 to 5175
50-cut.....	5000	4600 to 5400	4250 to 5750

uction.—Based on the
aragraph (*g*), asbestos
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numbers which indi-
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the yarn is plain or

QUIREMENTS FOR
ND OF STANDARD
YARNS.

ermissible ariations in erage Yards per Pound	Permissible Variations in Yards per Pound of Single 30-yd Skein
60 to 540	425 to 575
52 to 648	510 to 690
44 to 756	595 to 805
36 to 864	680 to 920
28 to 972	765 to 1035
20 to 1050	850 to 1150
04 to 1296	1020 to 1380
88 to 1512	1190 to 1610
72 to 1728	1360 to 1840
56 to 1944	1530 to 2070
40 to 2160	1700 to 2300
24 to 2376	1870 to 2530
08 to 2592	2040 to 2760
92 to 2808	2210 to 2990
76 to 3024	2380 to 3220
60 to 3240	2550 to 3450
20 to 3780	2975 to 4025
80 to 4320	3400 to 4600
40 to 4860	3825 to 5175
00 to 5400	4250 to 5750

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zero, indicates plain
git is 1, 2, or 3, the
of wire twisted with
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digit designates the

its (1 or 2) designate

2-cut, 3-ply–1 wire yarn
3-cut, single, plain yarn
4-cut, 2-ply, plain yarn

Breaking Strength

3. The breaking strength of asbestos yarn shall be expressed in pounds and decimal fractions thereof and shall conform to:

(*1*) The specified average for the shipment,

(*2*) The allowed minus variation of the average, and

(*3*) The minimum specified for any individual break.

Yards Number (Cut)

4. (*a*) The yards per pound of the standard single asbestos yarns shall conform to the requirements as prescribed in Table I.

(*b*) The cut of reinforced asbestos yarn shall be determined without removing the reinforcing core yarn.

(*c*) The yards per pound of metallic asbestos yarn is less than that of plain yarn of the same cut in proportion to the weight of the inserted wire.

(*d*) The yards per pound of sized yarn, single or plied, shall be subject to an additional tolerance of −2 per cent in comparison with the corresponding untreated yarn.

Size of Wire

5. The diameter of the wire used in metallic asbestos yarn shall not vary from the size specified by more than ±0.001 in.

Twist

6. The directions and turns per inch of twist shall be as mutually agreed upon by the manufacturer and the purchaser.

Grades

7. (*a*) The grades of plain, metallic, and reinforced asbestos yarn shall be determined by the percentage of asbestos content by weight, and shall conform to the following requirements:

Grade	Asbestos Content
Commercial Grade	75 to 80 per cent, excl
Underwriters' Grade	80 to 85 per cent, excl
Grade A	85 to 90 per cent, excl
Grade AA	90 to 95 per cent, excl
Grade AAA	95 to 99 per cent, excl
Grade AAAA	99 to 100 per cent, incl

(*b*) The asbestos content of reinforced asbestos yarn shall be determined without removing the reinforcing core yarn.

(*c*) The asbestos content of metallic asbestos yarn shall be determined after the wire has been removed.

Electrical Properties

8. Yarns used for electrical insulation shall conform to the Specifications for Asbestos Textiles Used for Electrical Insulating Purposes (ASTM Designation: D 2100).[8]

METHODS OF TESTING

Test Conditions

9. All test specimens shall be brought to a standard condition in accordance with Section 2 (*e*) prior to testing, and all tests shall be made under the standard condition.

Sampling

10. (*a*) Unless otherwise specified, each shipment shall be divided into lots of 800 to 1000 lb. From each lot, or fraction thereof, five sample tubes shall be taken at random, preferably from more than two cases, and the tests prescribed for strength and yardage (Sections 11 and 12) shall be made on specimens from each package taken.

(*b*) If tests from any lot fail to fall within the specified limits for strength and yardage, two additional sets of five sample tubes each shall be taken from other parts of the lot and tested as before. Acceptance for breaking strength and yardage tests shall be on the basis of these two additional sets of five sample tubes being within the required limits.

[8] Appears in this publication.

(*c*) Optional with the purchaser, if the values as determined in accordance with Paragraph (*b*) fail to fall within the specified limits, the lot shall be subdivided into units of approximately 200 lb. These shall be sampled and tested for conformance in accordance with Paragraphs (*a*) and (*b*).

Breaking Strength

11. (*a*) *Apparatus.*—A tensile testing machine conforming to the Specifications for Textile Testing Machines (ASTM Designation: D 76).[3]

(*b*) *Procedure.*—All tests shall be made on single strands. Single strands shall be broken after conditioning the tubes for 12 hr in accordance with Section 2 (*e*). A single-strand tester of proper capacity, with the clamps set 10 in. apart and having a speed of pulling clamp of 12 ± ½ in. per min, shall be used. One break shall be made from each tube of each set of five tubes selected in accordance with Section 10. Care shall be taken to avoid loss of twist during the test. The holding device shall be of the drum or capstan type. All breaks within ½ in. of the contact points shall be discarded.

(*c*) *Calculation and Report.*—The allowed variation from the average of five individual tests shall be calculated as follows:

$$T = \frac{V}{\sqrt{5}}$$

where:

T = allowed minus variation of the average of any five tests and the specified average, and

V = spread between the specified minimum of any single break and the specified lot average.

Example.—Assumed that the specified average is 3 lb and minimum break is 2 lb, then

$$T = \frac{3 - 2}{\sqrt{5}}$$

$$T = 0.44$$

or, the average of any five tests at random should be not less than 2.56 lb.

Yarn Number (Cut)

12. The cut of plain or reinforced asbestos yarn, single or plied, shall be calculated by dividing by 100 the yards per pound as determined in accordance with Paragraphs (*a*) to (*c*).

(*a*) The yards per pound of plain or reinforced single asbestos yarn shall be determined by reeling a 30-yd skein from each of five tubes taken at random from each lot of 800 to 1000 lb. These five skeins shall be conditioned for at least 4 hr in accordance with Section 2 (*e*), and the weight of each skein shall then be determined to the nearest grain. The average yards per pound shall be the arithmetical average of the five determinations, calculated as follows:

$$Y = \frac{7000 \times 30}{W}$$

where:

Y = yards per pound, and

W = weight in grains of a 30-yd skein.

(*b*) The yards per pound of plied plain or reinforced asbestos yarn shall be determined by reeling a 30-yd skein from each of five tubes taken at random from each lot of 800 to 1000 lb. These five skeins shall be conditioned for at least 4 hr in accordance with Section 2 (*e*), and the weight of each skein shall then be determined to the nearest grain. The average yards per pound shall be the arithmetical average of the five determinations, calculated as follows:

$$Y = \frac{7000 \times 30 \times (\text{number of plies})}{W \times 0.95}$$

where:

Y = yards per pound of single ply,

W = weight in grains of a 30-yd skein, and

0.95 = factor to compensate for an average contraction of 5 per cent incurred in twisting.

(*c*) The yards per pound of metallic asbestos yarn, single, or plied, shall be determined by reeling a 30-yd skein from each of five tubes taken at random from each lot of 1000 to 1400 lb. These five skeins shall be conditioned for at least 4 hr in accordance with Section 2 (*e*), and the weight of each skein shall then be determined to the nearest grain. The weight in grains of the wire taken from one skein shall be determined. This weight shall be subtracted from the weight of each skein. The average yards per pound shall be the arithmetical average of the five determinations, calculated as follows:

$$Y = \frac{7000 \times 30 \times (\text{number of plies})}{W \times 0.95}$$

where:

Y = yards per pound,

W = weight in grains of 30-yd skein (without wire), and

0.95 = factor to compensate for an average contraction of 5 per cent incurred in twisting.

Twist

13. (*a*) *Direction of Twist.*—The direction of twist shall be determined in accordance with Section 2 (*f*).

(*b*) *Turns in Single Yarn.*—The turns per inch of twist in single yarn shall be determined on any standard single yarn twist tester. The first 2 yd of any package of yarn shall be discarded, and all possible care shall be exercised in handling samples to prevent a change in the existing twist. The yarn, drawn just taut enough to prevent sagging, shall be gripped in the twist counter with clamps set 4 in. apart. One clamp shall be rotated until the twist is removed as indicated by the yarn breaking under its own weight, or by visual examination of the sample. The twist of yarn in a shipment shall be the average of three tests from each of the five tubes or bobbins selected in accordance with Section 10 (*a*).

(*c*) *Turns in Plied Yarn.*—The turns per inch of twist in plied yarn shall be determined as described in Paragraph (*b*), with the following exception: The clamps shall be set 10 in. apart.

Asbestos Content

14. (*a*) Determine the asbestos content in accordance with the Method of Test for Asbestos Content of Asbestos Textile Materials (ASTM Designation: D 1918).[3]

(*b*) In making asbestos content determinations on asbestos yarns reinforced with continuous filament glass yarns, such insertion shall be removed before making the determination. The organic content shall be computed on the basis of the oven-dry weight of the glass reinforced yarn previous to removal of the glass yarn insert.

APPROVED AS
AMERICAN STANDARD L14.133-1966
BY AMERICAN STANDARDS ASSOCIATION

NOTE: ASTM Specifications and Methods of Test are subject to continual revision. Consult the Society's current "ASTM Standards on Textile Materials" for possible changes in this specification.

Tentative Specification and Tolerances for

WOVEN ASBESTOS CLOTH[1]

ASTM Designation: D 1571 - 66 T

ISSUED, 1958; REVISED, 1966

This Tentative Specification has been approved by the sponsoring committee and accepted by the Society in accordance with established procedures, for use pending adoption as standard. Suggestions for revisions should be addressed to the Society at 1916 Race St., Philadelphia, Pa. 19103.

1. Scope

1.1 This specification covers woven asbestos cloth having a minimum of 75 per cent asbestos fiber by weight, excluding the weight of other inorganic reinforcing strands which may be present.

NOTE 1—Specifications for asbestos yarns are covered in ASTM Specification D 299, for Asbestos Yarn.[2]

2. Definitions

2.1 *Asbestos Fiber, n.*—For purposes of this specification, asbestos fiber is the hydrous magnesium silicate serpentine mineral identified as chrysotile and having the general empirical formula $Mg_3Si_2O_5(OH)_4$.

2.2 For definitions of other terms used in this specification, refer to ASTM Definitions D 123, Terms Relating to Textile Materials.

3. Classification

3.1 The classes of asbestos cloth are based on the nature of the yarns from which they are woven.

3.1.1 *Class A*—Cloth constructed of asbestos yarns containing no reinforcing strands.

3.1.2 *Class B*—Cloth constructed of asbestos yarns containing wire reinforcement.

3.1.3 *Class C*—Cloth constructed of asbestos yarns containing organic reinforcing strands.

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

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

3.2 *Grades*—The grades of asbestos cloth are based on the percentage of asbestos content by weight as stated in Table 1.

4. Basis of Purchase

4.1 Woven asbestos cloth is normally purchased on the basis of class, grade, weave, weight, thickness, and width as

[1] Under the standardization procedure of the Society, this specification is under the jurisdiction of the ASTM Committee D-13 on Textile Materials, and is the direct responsibility of Subcommittee A-4 on Asbestos and Its Textile Products.

[2] Appears in this publication.

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normally furnished in rolls of 50 or 100 yards (45 or 90 m).

5. Materials and Manufacture

5.1 *Yarn*—Asbestos cloth shall be uniformly woven from a specified grade of asbestos yarn with or without reinforcement.

5.2 *Wire Reinforcements*—The wire reinforcement may be brass, copper, zinc, or other metal or alloy as specified in the order.

TABLE 1—GRADES OF WOVEN ASBESTOS CLOTH.

Grade	Asbestos Content, weight per cent
Commercial	75 to 80, excl
Underwriters	80 to 85, excl
A	85 to 90, excl
AA	90 to 95, excl
AAA	95 to 99, excl
AAAA	99 to 100, incl

5.3 *Organic Reinforcements*—The organic reinforcements may be cotton, nylon, rayon or other spun or filament yarns as specified in the order.

5.4 *Inorganic Reinforcements*—The inorganic reinforcement may be glass, or other ceramic or vitreous spun or filament yarns as specified in the order.

6. Physical Requirements and Tolerances

6.1 The physical properties of woven asbestos cloth shall conform to the requirements as specified in the order, subject to the following tolerances:

6.1.1 *Width*—The width of asbestos cloth shall be within the following limits:

Nominal Width	Permissible Limits
Up to and including 40 in. (1 m)	±0.5 in. (12 mm)
Over 40 in. up to and including 60 in. (1.5 m)	±0.75 in. (19 mm)
Over 60 in.	±1.00 in. (25 mm)

6.1.2 *Thickness*—The thickness of asbestos cloth shall be within the following limits:

Nominal Thickness	Permissible Limits
0.050 in. (1.27 mm) and under	±0.005 in. (0.12 mm)
Over 0.050 in. (1.27 mm)	+0.010 in. (0.25 mm) −0.005 in. (0.12 mm)

6.1.3 *Weight*—The weight of asbestos cloth shall be within ±7 per cent of the specified weight.

TABLE 2—LOT SAMPLE.

Number of Rolls in Lot or Shipment	Number of Rolls to be Taken for Test
1	1
2 to 8	2
9 to 15	3
16 to 40	4
41 to 65	5
66 rolls and over	10 per cent of shipment rounded off to the next higher integer

6.1.4 *Fabric Count*—The warp ends or filling picks shall be within the following limits:

Ends or Picks per inch	Permissible Limits
20 or less per inch	±1 end or pick per inch
More than 20 per inch (25 mm)	±5 per cent of the specified count.

6.1.5 *Yarn Number (Cut)*—The yarn number (cut) shall be as specified and shall conform to the requirements stated in ASTM Specification D 299.[3]

6.1.6 *Asbestos Content*—The asbestos content of the particular grade specified shall conform to the limits stated in Table 1.

6.1.7 *Breaking Strength*—The breaking strength (breaking load) of asbestos cloth shall be as agreed upon between the buyer and seller.

6.1.8 *Electrical Properties*—Cloth to be used for electrical insulating purposes shall conform to the requirements in ASTM Specification D 2100, Asbestos

Textiles Used for Electrical Insulating Purposes.[2]

7. Sampling

7.1 From each lot of cloth, take a lot sample in a random manner to be representative of the lot in accordance with the schedule in Table 2. Cut a specimen from each roll taken for test, each specimen to be the full width of the roll and at least 0.5 yd (0.5 m) long. The specimen may be taken from the cut end of the roll.

8. Conditioning

8.1 Condition all specimens (without preconditioning) for a period of 4 hr, or until the specimen shows no progressive change in weight of more than 0.1 per cent after an exposure of 0.5 hr, in an atmosphere having a relative humidity of 50 ± 2 per cent at 70 ± 2 F (21 ± 1.1 C).

9. Methods of Test

9.1 *Width*—Measure the width of the cloth, either on the full roll or on a short specimen from each roll taken for test, as directed in ASTM Methods D 1910, Tests for Construction Characteristics of Woven Fabrics.[3]

9.2 *Thickness*—Measure the thickness of the cloth as directed in ASTM Method D 1777, for Measuring Thickness of Textile Materials.[3] Use a gage of the deadweight type equipped with a dial graduated to read directly to 0.001 in. (0.025 mm), and having a circular presser foot with a diameter of 0.375 ± 0.001 in. (9.5 ± 0.025 mm). The presser foot and moving parts connected therewith shall be weighted so as to apply a total load of 6 ± 0.1 oz. (170 ± 3 g) equivalent in pressure to 3.4 psi (0.24 kg/cm²) to the specimen. Make ten thickness measurements on a specimen from each roll taken for test and report the calculated average of all measurements as the average thickness of the lot. Make no measurement within 3 in. (76 mm) of any edge of the specimen, and distribute the places of measurement approximately uniformly over the specimen.

9.3 *Weight*—From each roll taken for test, cut a specimen not less than 0.5 yd (0.5 m) in length and across the full width of the cloth, measuring the length and width of the specimen to the nearest 0.1 in. (2.5 mm) in at least three places, using a steel tape or rigid rule. Make sure that the specimen is free from tension, wrinkles, and folds. Weigh the specimen to the nearest 0.01 oz (0.3 g). Using the average length and average width, calculate and report the weight in ounces per square yard (kilograms per square meter) on the basis that the weight per square yard (square meter) of the lot of cloth is equivalent to the arithmetic mean of the results.

9.4 *Fabric Count*—Determine the fabric count on one or more specimens from each roll taken for test, as directed in ASTM Method D 1910.

9.5 *Asbestos Content*—Determine the asbestos content on one or more specimens from each roll taken for test as directed in ASTM Method D 1918, Test for Asbestos Content of Asbestos Textile Materials.[3]

9.6 *Breaking Strength (Load)*—Determine the breaking load by the grab method as directed in ASTM Method D 1682, Test for Breaking Load and Elongation of Textile Fabrics.[3] Use a CRT—constant rate of traverse type tensile testing machine operated at 12 ± 0.5 in. (305 ± 12 mm) per minute. If agreed upon between the buyer and seller, a CRE—constant rate of elongation type machine may be used.

10. Conformance

10.1 If the test results for the lot conform to the requirements for all charac-

[3] *1966 Book of ASTM Standards*, Part 24.

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eristics listed in 6.1.1 through 6.1.8 inclusive, the lot shall be considered acceptable.

10.2 If the test results for one or more characteristics do not conform to the requirements, take a new laboratory sample from either the original lot sample or a new lot sample. Test the new sample for the characteristic(s) that did not conform to the requirements in the first test and average the results of the first a second samples as if they were one test double the original number of specime If the new average(s) conform(s) to t specified requirements, the lot shall considered acceptable.

10.3 If the test results obtained as rected in 10.2 do not conform to t specified requirements, the lot shall considered unacceptable.

NOTE: ASTM Specifications and Methods of Test are subject to continual revision. Consult the Society's current "ASTM Standards on Textile Materials" for possible changes in this specification.

Tentative Specification and Tolerances for

WOVEN ASBESTOS TAPE[1]

ASTM Designation: D 315 – 66 T

ISSUED, 1958; LAST REVISED, 1966

This Tentative Specification has been approved by the sponsoring committee and accepted by the Society in accordance with established procedures, for use pending adoption as standard. Suggestions for revisions should be addressed to the Society at 1916 Race St., Philadelphia, Pa. 19103.

1. Scope

1.1 This specification covers woven asbestos tape having a minimum of 75 per cent asbestos fiber by weight, excluding the weight of other inorganic reinforcing strands which may be present.

NOTE 1—Specifications for asbestos yarns are covered in ASTM Specification D 299, for Asbestos Yarn.[2]

2. Definitions

2.1 *Asbestos Fiber, n.*—For purposes of this specification, asbestos fiber is the hydrous magnesium silicate serpentine mineral identified as chrysotile and having the general empirical formula $Mg_3Si_2O_5(OH)_4$.

2.2 For definitions of other terms used in this specification, refer to ASTM Definitions D 123, Terms Relating to Textile Materials.

3. Classification

3.1 *Classes*—The classes of asbestos tapes are based on the nature of the yarns from which they are woven.

3.1.1 *Class A*—Tape constructed of asbestos yarns containing no reinforcing strands.

3.1.2 *Class B*—Tape constructed of asbestos yarns containing wire reinforcement.

3.1.3 *Class C*—Tape constructed of asbestos yarns containing organic reinforcing strands.

3.1.4 *Class D*—Tape constructed of asbestos yarns containing non-metallic inorganic reinforcing strands.

3.1.5 *Class E*—Tape constructed of two or more of the yarns used in tape classes *A* through *D*.

3.2 *Grades*—The grades of asbestos tape are based on the percentage of asbestos content by weight as stated in Table 1.

4. Basis of Purchase

4.1 Woven asbestos tape is normally purchased on the basis of class, grade, weight, width, length, and thickness as specified in the order.

4.2 Rolls of asbestos tape are normally furnished in the following lengths:

[1] Under the standardization procedure of the Society, this specification is under the jurisdiction of the ASTM Committee D-13 on Textile Materials, and is the direct responsibility of Subcommittee A-4 on Asbestos and Its Textile Products.

[2] Appears in this publication.

Nominal Thickness	Nominal Roll Length
Up to and including 0.03 in. (0.76 mm)	36 yd (33 m)
Over 0.03 in. up to and including 1/16 in. (1.6 mm)	100 ft (30 m)
Over 1/16 in.	50 or 100 ft (15 or 30 m)

4.3 Special roll lengths shall be as agreed upon between the buyer and seller.

4.4 At least 90 per cent of the number of rolls in the lot shall be furnished as one piece. No roll shall contain more than two pieces. The shortest piece shall not be less than 20 per cent of the specified nominal roll length.

TABLE 1—GRADES OF WOVEN ASBESTOS TAPE.

Grade	Asbestos Content, weight per cent
Commercial	75 to 80, excl
Underwriters	80 to 85, excl
A	85 to 90, excl
AA	90 to 95, excl
AAA	95 to 99, excl
AAAA	99 to 100, incl

5. Materials and Manufacture

5.1 *Yarn*—Asbestos tape shall be uniformly woven from a specified grade of asbestos yarn with or without reinforcement.

5.2 *Wire Reinforcement*—The wire reinforcement may be brass, copper, zinc, or other metal or alloy as specified in the order.

5.3 *Organic Reinforcement*—The organic reinforcement may be cotton, nylon, rayon, or other spun or filament yarns as specified in the order.

5.4 *Inorganic Reinforcement*—The inorganic reinforcement may be glass, or other ceramic or vitreous spun or filament yarns as specified in the order.

5.5 It is permissible to use a maximum of two ends of yarn other than asbestos in each selvage.

6. Physical Requirements and Tolerances

6.1 The physical properties of woven asbestos tape shall conform to the requirements as specified in the order, subject to the following tolerances:

6.1.1 *Width*—The width of asbestos tape shall be within the following limits

Nominal Width	Permissible Limits
Up to and including 1 in. (25.4 mm)	±1/16 in. (1.6 mm)
Over 1 in. up to and including 3 in. (76 mm)	±3/32 in. (2.4 mm)
Over 3 in.	±1/8 in. (3.2 mm)

6.1.2 *Thickness*—The thickness of asbestos tape shall be within the following limits:

Nominal Thickness	Permissible Limits
Up to and including 0.03 in. (0.76 mm)	±0.003 in. (0.07 mm)
Over 0.03 in. up to and including 1/16 in. (1.6 mm)	±0.005 in. (0.12 mm)
Over 1/16 in.	+0.010 in. (0.25 mm) −0.005 in. (0.12 mm)

6.1.3 *Weight*—The weight of asbestos tape shall be within ±10 per cent of the specified weight.

6.1.4 *Fabric Count*—The total number of warp ends and filling picks per inch shall be within the following limits:

Total Warp Ends	Permissible Limits
All widths	±10 per cent of the specified number of ends.
Picks per Inch	
20 or less per inch (25 mm)	±1 pick per inch
More than 20 per inch	±5 per cent of the specified filling count.

6.1.5 *Yarn Number (Cut)*—The yarn number (cut) shall be as specified and shall conform to the requirements stated in ASTM Specification D 299.[2]

6.1.6 *Asbestos Content*—The asbestos content of the particular grade specified shall be in accordance with the limits stated in Table 1.

6.1.7 *Breaking Strength*—The breaking strength (breaking load) of asbestos tape shall be as agreed upon between the buyer and seller.

6.1.8 *Electrical Properties*—Tape to be used for electrical insulating purposes shall conform to the requirements in ASTM Specification D 2100, for Asbestos Textiles Used for Electrical Insulating Purposes.[3]

7. Sampling

7.1 From each lot of tape, take a lot sample in a random manner to be representative of the lot in accordance with the schedule in Table 2. Cut a specimen from each roll taken for test, each specimen to be the full width of the tape and at least 5 ft. (1.5 m) long. The specimen may be taken from the cut end of the roll.

TABLE 2—LOT SAMPLE.

Number of Rolls in Lot or Shipment	Number of Rolls to be Taken for Test
50 and under	3
51 to 100	5
101 to 250	7
251 to 500	10
501 to 700	12
701 to 1000	15
1001 rolls and over	2 per cent of shipment rounded off to the next higher integer.

8. Conditioning

8.1 Condition all specimens (without preconditioning) for a period of 4 hr, or until the specimen shows a progressive change in weight of no more than 0.1 per cent after an exposure of 0.5 hr, in an atmosphere having a relative humidity of 50 ± 2 per cent at 70 ± 2 F (21 ± 1.1 C).

9. Methods of Test

9.1 *Width:*

9.1.1 Measure the width of the tape on each roll taken for test by the use of a standard steel rule graduated in $\frac{1}{16}$-in. (1 mm in the case of a metric rule) or finer divisions. Make the measurements while the tape lies flat and without tension on a smooth surface. Make five measurements at least 1 ft (30 cm) apart in each roll.

9.1.2 Report the average of the measurements on all rolls as the width of the lot under test.

9.2 *Thickness:*

9.2.1 Measure the thickness of the tape as directed in ASTM Method D 1777, for Measuring Thickness of Textile Materials.[4] Use a gage having a circular presser foot with a nominal diameter of 0.375 in. (9.5 mm). The presser foot and moving parts shall be weighted so as to apply a total load of 6 ± 0.1 oz. (170 ± 3 g) equivalent in pressure to 3.4 psi (0.24 kg/cm²) to the specimen. Make ten thickness-measurements on a specimen from each roll taken for test distributed approximately uniformly along the specimen. Make no measurement on the selvage edge of the specimen.

9.2.2 Report the average of all measurements as the average thickness of the lot.

9.3 *Weight:*

9.3.1 From each roll taken for test, cut a specimen not less than 5 ft (1.5 m) in length and the full width of the tape, measuring the length of the specimen to the nearest 0.1 in. (2.5 mm), using a steel tape or rigid rule. Make sure that the specimen is free from tension, wrinkles, and folds. Weigh the specimen to the nearest 0.01 oz. (0.3 g). Using the average length and weight, calculate the weight in lb/100 ft (kg/100 m).

9.3.2 Report the calculated weight in lb/100 ft as the weight of the tape.

9.4 *Fabric Count:*

9.4.1 *Ends*—Determine the total number of ends regardless of the width of the tape.

9.4.2 *Picks*—Determine with the aid of a thread count magnifying glass the number of picks per inch (25.4 mm) over

[3] Appears in this publication.

[4] *1960 Book of ASTM Standards*, Part 24.

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length of 3 in. (76 mm) in each of five different places along the specimen.

9.4.3 Report the average number of ends per inch observed for all specimens.

9.5 *Asbestos Content:*

9.5.1 Determine the asbestos content of one or more specimens from each roll taken for test as directed in ASTM Method D 1918, Test for Asbestos Content of Asbestos Textile Materials.[2]

9.6 *Breaking Strength (Load):*

9.6.1 Determine the breaking load, as directed in 9.6.2 and 9.6.3. Use a specimen about 6 in. (150 mm) long and a nominal gage length of 3 in. (75 mm). Use a CRT—constant rate of traverse type tensile testing machine operated at 12 ± 0.5 in. (305 ± 12 mm) per min. If agreed upon between the buyer and seller, a CRE—constant rate of elongation machine may be used.

9.6.2 *Tapes up to and Including 1.5 in. (38 mm) Wide*—Make five tests full width in the warp direction using clamps having a nominal width of 2 in. (50 mm).

9.6.3 *Tapes over 1.5 in. Wide*—Make five tests in the warp direction. Use clamps with jaw faces at least as wide as the specimen and insert the specimen in the clamps as directed in ASTM Method D 1682, Test for Breaking Load and Elongation of Textile Fabrics (grab method).[4]

9.6.4 Report the average of the results as the breaking load of the lot tested.

10. Conformance

10.1 If the test results for the lot conform to the requirements for all characteristics listed in 6.1.1 through 6.1.8 inclusive, the lot shall be considered acceptable.

10.2 If the test results for one or more characteristics do not conform to the requirements, take a new laboratory sample from either the original lot sample or a new lot sample. Test the new sample for the characteristic(s) that did not conform to the requirements in the first test and average the results of the first and second samples as if they were one test of double the original number of specimens. If the new average(s) conform(s) to the specified requirements, the lot shall be considered acceptable.

10.3 If the test results obtained as directed in 10.2 do not conform to the specified requirements, the lot shall be considered unacceptable.

NOTE: ASTM Specifications and Methods of Test are subject to continual revision. Consult the Society's current "ASTM Standards on Textile Materials" for possible changes in this specification.

Tentative Specification for

ASBESTOS TEXTILES USED FOR ELECTRICAL INSULATING PURPOSES[1]

ASTM Designation: D 2100 – 66 T

ISSUED, 1962; REVISED, 1966

This Tentative Specification has been approved by the sponsoring committee and accepted by the Society in accordance with established procedures, for use pending adoption as standard. Suggestions for revisions should be addressed to the Society at 1916 Race St., Philadelphia, Pa. 19103.

1. Scope

1.1 This specification covers asbestos textile materials used for electrical insulating purposes having a minimum of 80 per cent asbestos fiber, by weight, excluding the weight of other inorganic reinforcing material which may be present.

NOTE 1—Specifications for other asbestos textiles are covered in ASTM Specification D 299 for Asbestos Yarns;[2] Specification D 315, for Woven Asbestos Tape;[2] Specification D 375, for Asbestos Roving;[2] Specification D 1061, for Asbestos Lap;[2] and Specification D 1571 for Woven Asbestos Cloth.[2]

2. Definitions

2.1 *Asbestos Fiber, n.*—For purposes of this specification, asbestos fiber is the hydrous magnesium silicate serpentine mineral identified as chrysotile, and having the general empirical formula $Mg_3Si_2O_5(OH)_4$.

2.2 For definitions of other terms used in this specification, refer to ASTM Definitions D 123, Terms Relating to Textile Materials.

3. Classification

3.1 *Types*—The types of asbestos textiles used for electrical insulating purposes are based on the following magnetic rating:

Type	Maximum Magnetic Rating
II	0.75
IV	2.0
VI	4.0

3.2 *Grades*—The grades of asbestos textiles used for electrical insulating purposes are based on the percentage of asbestos content by weight as stated in Table 1.

4. Significance of Types and Grades

4.1 The types of asbestos textiles roughly define the electrical characteristics of the material. Generally, the higher the magnetic rating, the poorer

[1] Under the standardization procedure of the Society, this specification is under the jurisdiction of the ASTM Committee D-13 on Textile Materials, and is the direct responsibility of Subcommittee A-4 on Asbestos and Its Textile Products.

[2] Appears in this publication.

electrical insulating properties of the terial. The three types have the following intended applications:

4.1.1 Type II is intended for special applications where the asbestos is of primary importance as electrical insulation used on magnet wire and when used secondarily as a dielectric.

4.1.2 Type IV is intended for use where the asbestos is of secondary importance as electrical insulation or where, as primary electrical insulation, it is applied in relatively heavy thickness, usually in combination with other materials of comparably high dielectric strength, as in the construction of heat

TABLE 1—GRADES OF ASBESTOS TEXTILES USED FOR ELECTRICAL INSULATING PURPOSES.

Grade	Asbestos Content, weight per cent
Underwriters	80 to 85, excl
A	85 to 90, excl
AA	90 to 95, excl
AAA	95 to 99, excl
AAAA	99 to 100, incl

and flame-resistant electrical insulating walls over unit conductors of electrical cables.

4.1.3 Type VI is intended for use where the asbestos is of minor importance as a dielectric, as in fillers for heat- and flame-resistant cables, over-all wraps or braids for such cables, and linings for enclosures subject to exposure to electric arcs.

4.2 The grade of asbestos textile used is largely dependent on the service temperature required of the insulation. Specific temperature limits for the various grades cannot be given as this will depend on the textile construction. In general, the higher the asbestos content, the higher the temperature the textile will withstand.

NOTE 2—Where breaking strength retention is important, good serviceability at temperatures up to approximately 1000 F (540 C) can be expected using the higher grades. If breaking strength retention is not important, asbestos textiles may be used in excess of 1500 F (815 C), depending on the application.

5. Basis of Purchase

5.1 Asbestos textiles used for electrical insulating purposes are normally purchased on the basis of type and grade.

6. Materials and Manufacture

6.1 Asbestos textiles used for electrical insulating purposes shall be free of foreign matter not normally present in textiles, which may be detrimental to performance.

7. Physical Requirements

7.1 In addition to the requirements of this specification, asbestos textiles to be used for electrical insulating purposes shall meet the requirements of the appropriate ASTM specification for that particular asbestos textile product (see Note 1).

7.2 Asbestos textiles that have been treated with materials to impart certain desirable characteristics, such as moisture resistance, flame resistance, and improved electrical insulating properties, shall conform to the requirements of this specification and also to the applicable ASTM specification for that particular asbestos textile, prior to treatment, or after removal of the treating material by appropriate methods.

8. Methods of Test

8.1 *Magnetic Rating*—Determine the magnetic rating as directed in ASTM Method D 1118, Magnetic Rating of Asbestos Used for Electrical Purposes.[2]

8.2 *Asbestos Content*—Determine the asbestos content on specimens from each lot or unit taken for test, as directed in

ASTM Method D 1918, Asbestos Content of Asbestos Textile Materials.[2]

9. Certification

9.1 When agreed upon in writing by the purchaser and the seller, a certification shall be made the basis of acceptance of the material. This shall consist of a copy of the manufacturer's test report or a statement by the seller, accompanied by a copy of the test results, that the material has been sampled, tested, and inspected in accordance with the provisions of the specification. Each certification so furnished shall be signed by an authorized agent of the seller or manufacturer.

9.1.2 When the original identity cannot be established, certification can be based only on the sampling procedure provided by the applicable specification.

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UDC 621.315.613.2:620.179.1

Standard Method of Test for

MAGNETIC RATING OF ASBESTOS USED FOR ELECTRICAL PURPOSES[1]

ASTM Designation: D 1118 - 57

ADOPTED, 1957

This Standard of the American Society for Testing and Materials is issued under the fixed designation D 1118; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval.

Scope

1. This method covers two procedures for determining the magnetic rating of asbestos used for electrical purposes. The free iron and magnetic iron oxide (Fe_3O_4) is determined by a magnetic analyzer and is expressed empirically as magnetic rating (MR). Experience has shown that when used for electrical insulation it is desirable that asbestos have a low magnetic rating. The two procedures described in this method are both based on the principle of comparing the electromagnetic effect of an unknown sample of asbestos with the electromagnetic effect of a known standard.

Calibrating Standards

2. (*a*) A magnetic analyzer covering the usual range of magnetic rating (MR) is designed for two sensitivities: one with a full scale deflection equal to an MR of one, and the other with a full scale deflection equal to an MR of six. The sensitivity is controlled by a transfer switch incorporated in the apparatus. For the initial calibration, three to five standards, differing in value to cover the test range of the scale, shall be used. A calibrating standard with an MR of one contains 0.18 g. of National Bureau of Standards standard sample No. 29*a* of iron ore magnetite[2] uniformly distributed over the space occupied by a specimen under test ($\frac{3}{4}$ in. in diameter by $2\frac{1}{8}$ in. in length). For preparing calibrating standards of different values, the amount of magnetite shall be varied directly with the value of the desired standard (Note). The calibrating standards shall conform to the following requirements: Since the amount of magnetite used in a calibrating standard is not sufficient to fill the space needed for a test specimen, the magnetite shall be thoroughly mixed with an inert material such as zinc oxide so that it will pack firmly in the space provided. The containers for the calibrating standards shall be made of a nonmagnetic and nonmetallic material and have a chamber for the standard mixture with the same di-

[1] Under the standardization procedure of the Society, this method is under the jurisdiction of the ASTM Committee D-13 on Textile Materials, and is the direct responsibility of Subcommittee A-4 on Asbestos and Its Textile Products.

[2] Standard sample No. 29*a* is no longer available from the National Bureau of Standards. A new standard magnetite sample suitable for this test is available from the General Electric Co. Mr P O Nicodemus Wire and Cable Dept Lowell Mass.—ED.

mensions as the space in the test specimen holder. A convenient container is a wooden tube 1 in. in outside diameter with an inside diameter of $\frac{3}{4}$ in. and a length of $4\frac{1}{8}$ in. with two end plugs $\frac{3}{4}$ in. in diameter by 1 in. in length. One plug shall be cemented in place before, and the other after, the standard material is packed. The cement used shall be nonmagnetic.

NOTE.—In setting up the calibrating standards it is desirable to have the magnetic rating equivalent to the percentage of magnetic material present in the specimen to be tested. Because of the variation in the permeability of the oxides, it may not be possible to accomplish this accurately.

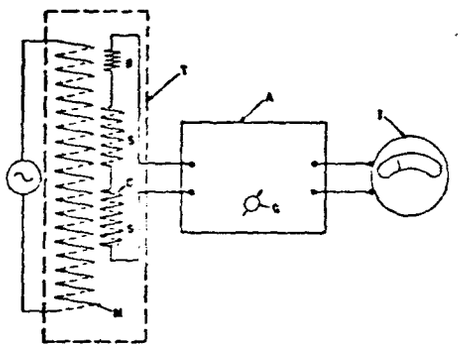
(*b*) Secondary standards for routine measurements can be made using smaller containers, that will fit in the test specimen holder, and having sufficient magnetite to give a deflection equal to the calibrating standard corresponding to the maximum scale value. One secondary standard is necessary for each scale range.

PROCEDURE A

Principle of Operation of Apparatus

3. A schematic drawing of the apparatus for Procedure A is shown in Fig. 1. The apparatus consists of a testing solenoid *T* having a primary winding *M* to produce a strong magnetic field, and secondary windings *S* and *B* to measure the change of flux caused by the specimen, a class A audio amplifier, *A*, to increase the signal sufficiently to operate an indicating instrument *I*. This apparatus operates from a 115-v., 60-cycle power supply.

The secondary winding *S* is wound in two equal sections and connected so that their voltages oppose each other when the primary winding *M* is energized. Coil *B* is used in series with *S* to balance out any small voltage difference between the two sections, so that the voltage to the amplifier is zero when no specimen is in the coil. Under this condition, a small amount of magnetic material in one section of *S* will cause a small voltage at the input to the amplifier due to the increased magnetic flux in that section. This voltage is amplified sufficiently by *A* to be read by Instrument *I*. It has been found that the readings of *I* are nearly directly proportional to the magnetic rating up to a magnetic rating of six.



T —Test solenoid
M —Magnetizing coil
S —Secondary coils
B —Balancing coil
C —Test sample
~—Alternating current source
A —Amplifier
G —Amplifier gain control
I —Indicating instrument

FIG. 1.—Schematic Diagram of Apparatus for Procedure A.

The primary and secondary windings of the testing solenoid, the amplifier gain, and the indicating instrument sensitivity can be varied as long as the over-all amplification is sufficient to give a full-scale deflection for the standard corresponding to the maximum scale value.

Testing Solenoid

4. The testing solenoid shall have a primary winding of 17 layers of 0.057-in. enameled single cotton covered copper wire (approximately 4200 turns). This coil shall be wound on a compound tube $2\frac{1}{2}$ in. in outside diameter with an inside diameter of 2 in., a length of 18 in., and

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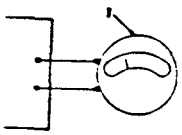

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Energize the primary coil from a 115-v., 60-cycle source and measure the voltages across the secondary coils. Then connect these coils in series so that their combined voltage is near zero. Then using a more sensitive indicating instrument, remove turns from the stronger section one turn at a time until it is within one turn of being exactly equal to the other section. Then wind the sliding coil with a sufficient number of turns so that the sections are exactly balanced at some point within its limits of motion and unbalanced in opposite directions at the extreme positions the sliding coil can take. This final balancing is usually made with the complete analyzer apparatus and the proper balance is indicated when the indicating instrument will show an appreciable deflection with the balance and then decrease to approximately zero and then increase to an approximately equal unbalance as the coil is moved to its other extreme limit.

Test Specimen Holder

5. Test specimens shall be placed in a holder to facilitate setting them in and removing them from the testing solenoid. This specimen holder shall be slightly less than 1 in. in diameter so that it will easily slide inside the secondary coil. It shall be made with a handle at one end and a cork at the other end leaving a space ¾ in. in diameter by 2½ in. in length for the test specimen. The handle shall be made with a stop and its length shall be such that the specimen holder is centrally located under the nearest section of the secondary winding when the stop is against the solenoid.

Amplifier

6. The amplifier shall be a two-stage resistance-coupled class A amplifier, using a pentode (type 57) for the first stage and a triode (type 56) for the second stage. The input is transformer coupled with a high secondary-to-primary-turn ratio transformer. The secondary of the input transformer is shunted by a resistance to change from the high sensitivity scale to the low sensitivity scale. This shunt circuit is controlled by a switch mounted on the amplifier panel. The amplifier gain is controlled by varying the screen grid voltage of the type 57 tube with the potentiometer *G*, Fig. 1. The indicating instrument *I*, included in the amplifier, is a d-c. milliampere meter with a sensitivity of 1 ma. for a full scale deflection. This instrument is used with a copper oxide instrument rectifier for use on alternating current. It is coupled to a 30-henry choke in the output of the type 56 tube by means of two 2-μf capacitors.

Initial Calibration

instrument to balance the secondary windings. After this has been done adjust the over-all amplifier gain to give full-scale deflection on the high-sensitivity (MR1) scale, when an MR1 calibrating standard is in the testing solenoid and the gain control *G*, Fig. 1, is near its mid-position. (Before inserting the calibrating standard, balance the secondary voltage to a minimum.) Switch the amplifier to the low sensitivity (MR6) scale, insert the MR6 calibrating standard in the testing solenoid and adjust the shunt on the input transformer to give full-scale deflection with the gain control *G* at the same position as used in adjusting the first scale. Then recheck these adjustments to make sure the sensitivities are correct before calibrating the scales. Calibrate the scale by adjusting the equipment to give a full-scale deflection for the calibrating standard corresponding to its maximum value, then substitute other calibrating standards and record the deflection obtained with them. This shall be done on each scale. If desired, a special scale can then be marked according to these readings to eliminate correcting all subsequent readings made on the analyzer.

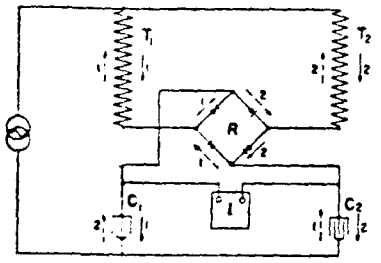

FIG. 2.—Schematic Diagram of Apparatus for Procedure B.

Procedure

8. After the initial calibration is completed, to determine the magnetic rating of a test specimen of asbestos, first energize the apparatus and permit it to warm up for a few minutes to become stable. Then balance the secondary coils with the balancing coil until the reflection on the indicating instrument is a minimum at full sensitivity. Decrease the sensitivity, place the calibrating standard for the range of test desired in the testing solenoid and adjust the amplifier gain control to give a full-scale deflection equal to the magnetic rating of the calibrating standard. Then remove the calibrating standard, place a 10-g. specimen of asbestos in the specimen holder and insert in the solenoid. The indicating instrument will then give the magnetic rating of the specimen.

PROCEDURE B

Principle of Operation of Apparatus

9. A schematic drawing of the apparatus for Procedure B is shown in Fig. 2. The apparatus consists of a series-parallel network of two duplicate test coils T_1 and T_2, two duplicate capacitors C_1 and C_2, a rectifying unit R, and an indicating instrument I. With an a-c. voltage impressed on the circuit, the current flow is as indicated by the arrows in Fig. 2. Arrows of solid lines indicate the current flow during the positive half cycles, and arrows of dotted lines indicate the current flow during the negative half cycles. A study of this diagram will show that due to the action of the rectifier, capacitor C_1 alternately carries the positive current of coil T_1 and the negative current of coil T_2 while capacitor C_2 alternately carries the positive current of coil T_2 and the negative current of coil T_1. Therefore, if the currents in both coils are equal, a stable condition exists and no current flows in the indicating circuit. If, however, the currents are unequal, a voltage difference will arise between the two capacitors causing a current to flow through the indicating instrument I.

Coils

10. The two coils shall be wound on a nonmagnetic and nonconducting coil

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form approximately 6 in. in length with an inside diameter of 1 to 2 in. and shall have several thousand turns each (Note). They shall be as nearly identical in resistance and inductance as is practicable.

NOTE.—In one satisfactory apparatus the coils were layer wound with 10,000 turns of 0.0179-in. enameled copper wire on a spool 6¼ in. in length with an inside diameter of 1¼ in. and having end flanges 4 in. in diameter by $\frac{1}{16}$ in. in thickness.

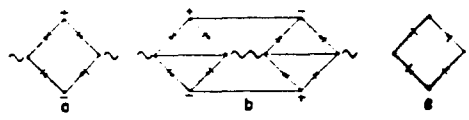

FIG. 3.—Schematic Diagram of Rectifiers and Connections for Procedure B.

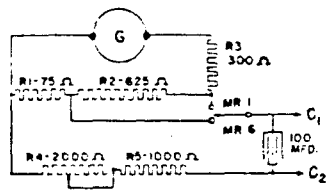

FIG. 4.—Schematic Diagram of Indicating Instrument for Procedure B.

Capacitors

11. The capacitors shall be of high quality and have equal reactances (Note).

NOTE.—In one satisfactory apparatus the capacitors were 10-μf. pyranol capacitors insulated for 330 v., a-c.

Rectifying Unit

12. The rectifier shall be made from two conventional full wave copper oxide rectifiers as shown in Fig. 3. Fig. 3 (*a*) is the conventional full wave rectifier with the d-c. terminals marked "+" and "—" and the a-c. terminals marked "~". Fig. 3 (*b*) shows the connections to be made between two conventional rectifiers to give the desired rectifying unit for this apparatus. Fig. 3 (*c*) is a simplified sketch of Fig. 3 (*b*) corresponding to the sketch of the rectifier unit in Fig. 2.

Indicating Instrument

13. The details of the indicating instrument are shown in Fig. 4. This shall consist of a portable galvanometer *G*, a resistance network for adjusting the over-all sensitivity and for changing the scale range, and a capacitor for by-passing any alternating current that may be present. The galvanometer shall have the following characteristics:

Galvanometer resistance, ohms	50
Period, sec	3
Sensitivity, μ amp. per 1-mm. scale division	0.040
Extreme critical damping resistance, ohms	700
Scale length, mm	100

The resistance network shall be made up of stable resistors having low-temperature coefficients. The values of these resistances are approximate as final adjustment must be made for the particular equipment being used. The capacitor shall be a 50-v. electrolytic capacitor.

Test Specimen Holder

14. The test specimen holder shall consist of a wooden tube 1 in. in outside diameter with an inside diameter of $\frac{3}{4}$ in. and a length of $4\frac{3}{8}$ in. and with two wooden stoppers that extend $\frac{3}{4}$ in. into each end of the tube.

Initial Calibration

15. (*a*) With this apparatus the balance is greatly affected by the proximity of any magnetic material, as such material changes the inductance of the coils. For this reason magnetic materials should not be used except those that are unavoidable and whose effect can be balanced out, such as the capacitors and the assembly bolts through the rectifier. If these parts are magnetic, the coils shall be mounted with their axes horizontal and parallel, with the capacitors and rectifiers located midway between them. There shall be at

least 3 in. between the sides of the coils and the capacitors. A simple balancing arrangement consists of a nonmetallic plug, capable of fitting tightly into the end of one of the coils, with a magnetic machine screw through its center. The center of the plug should be drilled and tapped so that the machine screw can be screwed in or out of the coil. A locking nut should be used to hold this screw in place after balance has been obtained. The length and size of this screw can be determined when the procedure described in Paragraph (*b*) is performed.

(*b*) For the initial balance, the sensitivity of the indicating instrument must be greatly reduced. This can be done by connecting a variable resistance of approximately 0 to 100 ohms across the instrument connections to the capacitors. Set the resistor at 0, shorting out the instrument, energize the circuit with a 115-v., 60-cycle supply, and then increase the resistance slightly until a few millimeters deflection is obtained on the galvanometer. It will then be found that bringing a magnetic screw near the end of one of the coils will cause the galvanometer deflection to decrease to zero and then reverse as the screw is pushed further into the coil. This indicates that the screw is bringing the coils into balance and then unbalancing them in the opposite direction. Then fit the plug into the desired coil and lock the screw in the position for zero balance. Increase the shunt across the instrument and adjust the balancing screw to maintain the balance until the coils are balanced with the resistance at its highest value. Remove the resistance and readjust the balance. The instrument resistances may now be adjusted to give the desired scale sensitivities. Place an MR1 calibrating standard in the test coil, throw the sensitivity switch to the MR1 position, and vary *R4* to give 100-mm. deflection. If desired, a smaller variable resistance can be placed in series with *R4* to give fine adjustment of the sensitivity. Throw the sensitivity switch to the MR6 position and place an MR6 calibrating standard in the test coil. Adjust *R1* keeping the sum of $R1 + R2 = 700$ ohms, until a 60-mm. deflection is obtained on the galvanometer. If calibrating standards of other MR values are available, other points on the scale can be checked and a correction curve obtained, although the deflections are nearly directly proportional to the MR values over the range of values used in this apparatus.

Procedure

16. Turn the sensitivity switch to the MR6 position, Fig. 4, and energize the apparatus with a 115-v., 60-cycle supply. Balance the apparatus by adjusting the balance screw to bring the galvanometer deflection to zero. Throw the sensitivity switch to the MR1 position, Fig. 4, and rebalance the apparatus, locking the balancing screw in place. Place the MR1 calibrating standard in the test coil and adjust the sensitivity to give a galvanometer deflection equivalent to an MR of one. Insert the 10-g. test specimen of asbestos in the test coil and read the resulting deflection of the galvanometer. If the deflection is off the scale, throw the sensitivity switch to the MR6 position and read the deflection.

NOTE.—The procedure here described is applicable only under those conditions wherein the magnetic particles being tested exhibit no directional properties or when the particle distribution is such as to give the ultimate in random orientation. The magnetic particles present in chrysotile asbestos, however, are most frequently needle-like or pseudo-fibrous and as such exhibit directional properties with regard to magnetic permeability. Therefore, there must be an understanding as to the extent of the fibrous characteristics and the grain size distribution of the magnetic particles present in

the sample under test if a proper evaluation of the resulting magnetic rating is to be truly factual. In view of the fibrous characteristics of the magnetic particles and the resultant directional magnetic properties, the method of sample preparation and the placement of the sample in the sample holder must be carefully pursued in an endeavor to obtain a test specimen that will exhibit a maximum in random orientation.

Calculation

17. The magnetic rating of the test specimen is proportional to the deflection, calculated as follows:

$$\text{MR for the MR1 scale} = \frac{\text{deflection}}{100} \times 1$$

$$\text{MR for the MR6 scale} = \frac{\text{deflection}}{60} \times 6$$

NOTE: ASTM Specifications and Methods of Test are subject to continual revision. Consult the Society's current "ASTM Standards on Textile Materials" for possible changes in this specification.

APPROVED AS
AMERICAN STANDARD
BY AMERICAN STANDARDS ASSOCIATION
ASA NO.: L14.41-1953
UDC 677.67:677.51:620.1

NOTE: ASTM Specifications and Methods of Test are subject to continual revision. Consult the Society's current "ASTM Standards on Textile Materials" for possible changes in this specification.

Standard Methods of

TESTING ASBESTOS TUBULAR SLEEVING[1]

ASTM Designation: D 628 – 52

ADOPTED, 1944; REVISED, 1952

This Standard of the American Society for Testing and Materials is issued under the fixed designation D 628; the final number indicates the year of original adoption as standard or, in the case of revision, the year of last revision.

NOTE.—Section 5 was revised and Section 6 was added editorially in June, 1962.

Scope

1. These methods of testing apply to woven and braided asbestos tubular sleeving.

Sampling

2. Asbestos tubular sleeving shall be sampled in accordance with Section 10 of the Methods of Testing and Tolerances for Tubular Sleeving and Braids (ASTM Designation: D 354).[2]

Test Condition

3. All test specimens shall be conditioned to moisture equilibrium in a standard atmosphere having a relative humidity of 50 per cent at 70 F (21 C). A tolerance of ±2 per cent is permitted in relative humidity and ±2 F (1.1 C) in temperature.

NOTE.—For purpose of tests, it is recognized that specimens reach moisture equilibrium after exposure for at least 4 hr at the above specified relative humidity and temperature.

Physical Properties

4. Determine the weight, wall thickness, inside diameter, carriers, ends per bobbin, yarn number, and imperfections in accordance with Sections 11 to 17, inclusive, of Methods D 354.

Asbestos Content

5. Determine the asbestos content in accordance with the Method of Test for Asbestos Content of Asbestos Textile Materials (ASTM Designation: D 1918).[3]

Electrical Properties

6. Asbestos sleeving used for electrical insulation shall conform to the Specification for Asbestos Textiles Used for Electrical Insulating Purposes (ASTM Designation: D 2100).[3]

[1] Under the standardization procedure of the Society, these methods are under the jurisdiction of the ASTM Committee D-13 on Textile Materials, and are the direct responsibility of Subcommittee A-4 on Asbestos and Its Textile Products.

[2] *1960 Book of ASTM Standards*, Part 24.

[3] Appears in this publication.

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NOTE: ASTM Specifications and Methods of Test are subject to continual revision. Consult the Society's current "ASTM Standards on Textile Materials" for possible changes in this specification.

Standard Method of Test for
HEAT AGING OF ASBESTOS TEXTILES[1]

ASTM Designation: D 1573 – 61

ADOPTED, 1961

This Standard of the American Society for Testing and Materials is issued under the fixed designation D 1573; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval.

Scope

1. (*a*) This method of test is intended for use in the evaluation of asbestos textiles with regard to (*1*) quality and (*2*) elevated temperature serviceability characteristics. Since asbestos textiles are usually composed of blends of asbestos with cotton, the latter being present in amounts up to 25 per cent, temperatures above 300 F will promote the degradation of the cotton content and will reduce the structural reinforcement derived therefrom. In the higher grade asbestos textiles, wherein little or no cotton is used and in which the longer asbestos fibers are necessary if a satisfactory yarn is to be produced, the degradation in strength resulting from heat-aging up to 1000 F is low. In the case of the lower grade asbestos textiles, however, wherein amounts from 15 to 25 per cent cotton are incorporated, asbestos fibers having shorter lengths may be utilized. Under the relatively low service temperatures to which such materials may be subjected, neither the cotton nor the cloth properties are greatly affected. However, the strength-imparting influence of the cotton is reduced at elevated temperatures and the entwining properties of the shorter asbestos fibers primarily serve to establish the resultant tensile strength and other physical properties of the textile. In view of this, elevated temperature tests may serve to indicate the asbestos fiber grade or quality which may be used in a textile construction.

(*b*) Another use and perhaps more practical application for the information to be derived from elevated temperature studies is the revelation of the ability of a subject textile to withstand known elevated temperature service conditions. It will be appreciated that temperature alone may not be the only degratory influence in the destruction of such materials; however, under normal operating conditions, high temperatures are usually the dominating factors in such degradation. The results obtained through such investigations therefore

[1] Under the standardization procedure of the Society, this method is under the jurisdiction of the ASTM Committee D-13 on Textile Materials, and is the direct responsiblity of Subcommittee A-4 on Asbestos and Its Textile Products.

may be interpreted in terms of elevated temperature serviceability.

Standard Test Oven

2. (*a*) The oven shall be electrically heated and have the necessary controls to maintain temperatures to within ±3 C (5.4 F) at any designated testing temperature up to 800 F and shall have determinable and controllable air circulation. The air circulation provisions shall be capable of delivering between 100 and 200 cu ft per min continuously to the oven during the testing period.

(*b*) The minimum inside dimensions of the oven shall be 18 by 18 by 18 in., and it shall be provided with two hardware cloth trays, $\frac{3}{4}$ in. mesh, 18 by 18 in. upon which the test specimens may be deployed.

Pretest Condition of Oven

3. (*a*) When starting a test, the oven temperature controls shall be set at the desired test temperature at the beginning of the heating-up period. The temperature indicating device shall be a chromel-alumel thermocouple, or its equivalent, coupled with an accurate potentiometer capable of being calibrated and adjusted to compensate for room temperature and cold junction differentials. The oven temperatures shall be determined by placing the junction of the thermocouple on a sample of cloth supported on the upper hardware cloth tray which will be located not less than 6 in. from the top of the oven nor less than 6 in. above the next lower tray.

(*b*) Air circulation shall be maintained continually from the beginning of the heating period throughout the test cycle. The initial heating-up period, during which no test specimens shall be in the oven, shall be maintained for a minimum of 2 hr or until such a time as the oven conditions have attained the degree of stability that will assure temperature variations no greater than prescribed in Paragraph (*a*).

METHOD OF TEST

Time and Temperature for Test

4. (*a*) All cloths shall be tested for a period of 2 hr.

(*b*) The temperature for testing shall be dependent upon the grade of the material under investigation, as follows:

Commercial Grade	400 F
Underwriter's Grade	400 F
Grade A	600 F
Grade AA	600 F
Grade AAA	800 F
Grade AAAA	800 F

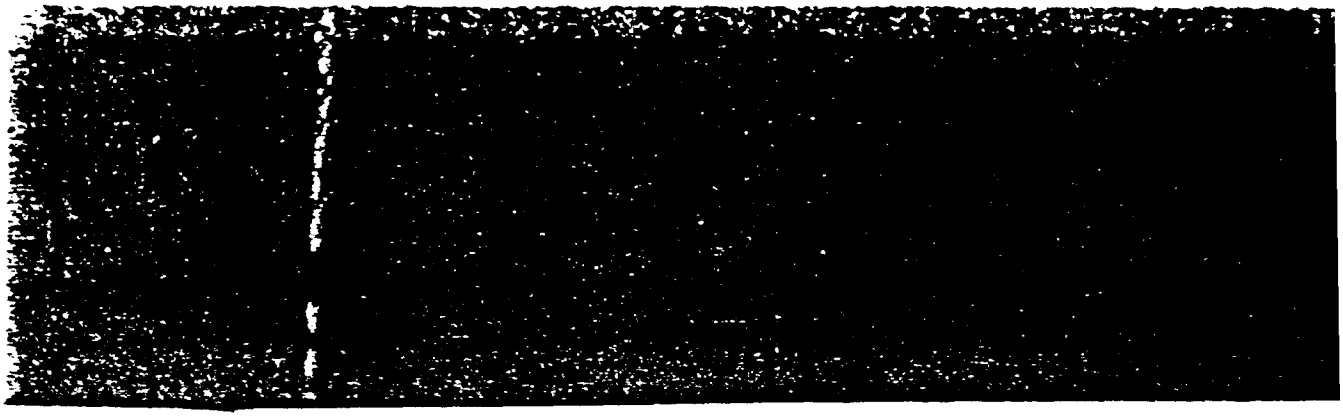
Deployment of Test Samples in Oven

5. Following the attainment of stabilized conditions, specimens of the samples under test shall be individually positioned on the wire mesh trays. There shall be not less than 6 in. separating the two trays as placed in the oven and not more than 6 in. between the top tray and the top of the oven or between the bottom tray and the bottom of the oven. With a hearth size 18 by 18 by 18 in., the individual trays will be 18 by 18 in. and on each may be positioned 12 individual grab test specimens. The placements shall be made as quickly as possible so that the oven door will remain open for a minimum length of time in order that the oven temperature may not drop markedly below the testing temperature.

Procedure

6. (*a*) Immediately upon closing the oven door begin the test period and continue the test for a predetermined time.

(*b*) Upon completion of the test period, remove the specimens from the oven and permit them to condition at room temperature for 35 ± 5 min. Following this conditioning period, test the specimens for tensile strength by a method



agreed upon by the purchaser and the seller. It is to be understood that tensile strength values (Note) and tensile strength retention values must be established on the basis of cloth constructions, as well as grade, and should be considered individually.

NOTE.—The determination of actual strength values and the decision as to whether such values of tensile strength shall be in terms of pounds break by the grab method or in terms of the percentage strength retention based on the grab test breaks are matters that can best be determined on the basis of the ultimate use to which such information is to be applied.

APPROVED AS
AMERICAN STANDARD L14.141-1963
BY AMERICAN STANDARDS ASSOCIATION
UDC 677.51:620.168:553.676

Tentative Method of Test for

ASBESTOS CONTENT OF ASBESTOS TEXTILE MATERIALS[1]

ASTM Designation: D 1918 – 62 T

ISSUED, 1962

This Tentative Method has been approved by the sponsoring committee and accepted by the Society in accordance with established procedures, for use pending adoption as standard. Suggestions for revisions should be addressed to the Society at 1916 Race St., Philadelphia 3, Pa.

Scope

1. (*a*) This method covers a procedure for determining the asbestos content of untreated chrysotile asbestos textile materials which are usually blends of asbestos and organic fibers. This method is applicable to treated asbestos textile materials only if the treatment can be completely removed, prior to testing, by appropriate methods, such as boiling in water or solvent extraction.

(*b*) This test is limited to those asbestos textile materials where asbestos is the only inorganic fiber present, or where any other inorganic fiber, such as continuous filament glass yarns used as reinforcement, can be removed prior to testing.

(*c*) If carbonates are present in the asbestos they shall be determined separately, and a corresponding correction shall be made to the loss on ignition before the asbestos content is calculated.

Summary of Method

2. (*a*) If carbonates are not present, a 5-g sample, dried to constant weight, is heated to 800 to 810 C (1470 to 1490 F) for 1 hr and the loss in weight is determined. The weight of the ignited sample divided by 0.86 is the weight of asbestos fiber originally present in the sample. This weight divided by the original sample weight is the asbestos content calculated as a percentage.

(*b*) If carbonates are present in the asbestos, the weight of carbon dioxide (CO_2) is determined by the Knorr alkalimeter. The asbestos content is determined as described in Paragraph (*a*), but the grams of CO_2 from a 1-g sample as determined in Section 9 must be subtracted from the factor 0.86 in calculating the results.

Definitions

3. (*a*) *Standard Atmosphere for Testing Asbestos Textiles, n.*—Air maintained at a relative humidity of 50 ± 2 per cent and at a temperature of 70 ± 2 F (21 ± 1.1 C).

(*b*) For definitions of other terms used in this method, see Definitions of Terms

[1] Under the standardization procedure of the Society, this method is under the jurisdiction of the ASTM Committee D-13 on Textile Materials, and is the direct responsibility of Subcommittee A-4 on Asbestos and Its Textile Products.

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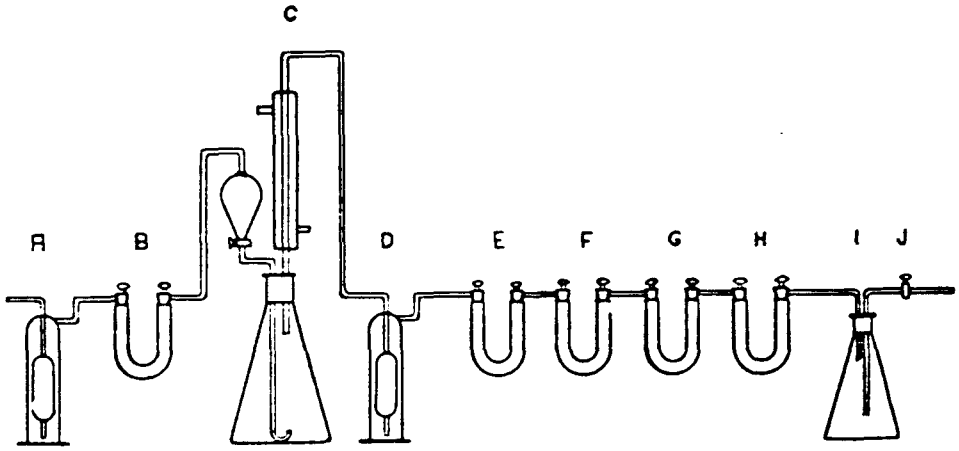

FIG. 1.—Knorr Alkalimeter for Determination of Carbon Dioxide.

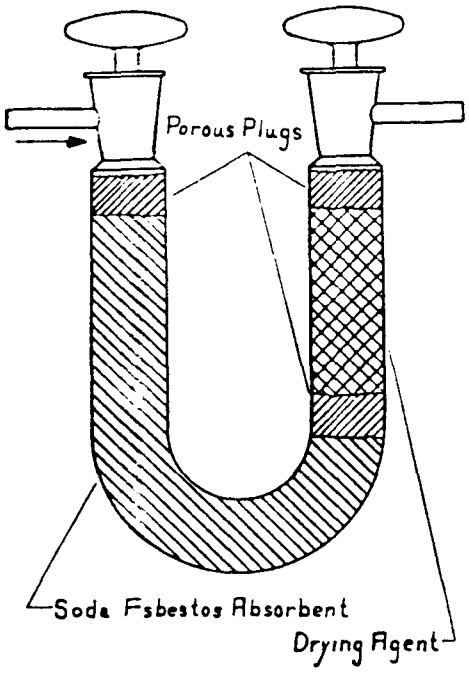

FIG. 2.—Absorption Tube for Carbon Dioxide Determination.

Relating to Textile Materials (ASTM Designation: D 123).

Significance

4. The asbestos content of asbestos textile materials is of major significance, as this determines the grade of the textile, which in turn indicates the approximate serviceability temperature for such materials.

Apparatus

5. (*a*) *Knorr Alkalimeter*, as described in the Appendix and shown in Figs. 1 and 2 for determining carbonates.

(*b*) *Oven*, capable of being held at a temperature between 800 to 810 C (1407 to 1490 F).

Test Specimens

6. The number of test specimens shall be as specified in the applicable ASTM specification for the material being tested. If the asbestos textile material has been reinforced with continuous filament glass yarns, the insertion shall be removed before making the determination.

Conditioning

7. Bring all test specimens to moisture equilibrium for testing in the standard atmosphere for testing asbestos textiles.

Procedure for Preliminary Test for Carbonates in Asbestos

8. (*a*) Determine if heat decomposable carbonates are present in the asbestos by running the qualitative test described in Paragraph (*b*).

(*b*) Place an approximately 0.5-g sample in a test tube (a 30 by 150-mm size is convenient) and wet well with 10 ml of distilled water by stirring and tamping with a glass rod, so that no air bubbles are visible in the wet sample. Add 5 ml of concentrated hydrochloric acid (HCl, sp gr 1.19) and again stir and tamp gently with a glass rod, taking care not to introduce any air bubbles. Warm slightly. The formation of gas bubbles on the surface of the submerged asbestos sample is a positive indication that carbonates are present, in which case the amount of CO_2 liberated by the carbonates must be determined by the method given in Section 9. If carbonates are not present, follow the procedure described in Section 10.

Procedure for CO_2 Liberated by Carbonates in Asbestos

9. (*a*) Check the Knorr alkalimeter (Fig. 1) to ensure freedom from leaks. Aspirate a current of air through the system at the rate of about two bubbles per minute for a period of 10 min. Stop the air current and remove the absorption tubes. Place the absorption tube *G* in the balance case and allow it to stand for several minutes. When ready for weighing, open the stopcocks momentarily and close. Weigh and repeat the above procedure. The second weight should agree with the first to within 0.0005 g. If it does not, repeat this process until the two successive weighings agree. When a constant weight is reached, replace the absorption tube in the gas train.

(*b*) Transfer about 1 g of the sample, weighed to the nearest 0.001 g, to the distillation flask. Wash down any adhering particles on the inside neck of the flask with distilled water. Add enough distilled water to the flask so that when the apparatus is reconnected the tip of the dropping funnel will be submerged about 5 to 10 mm. Place 50 ml of HCl (1:1) in the dropping funnel and replace the guard gas-absorption tube at the top of the funnel. Start the flow of water in the condenser and open all the stopcocks, *except* the one on the dropping funnel. Turn on the aspirator for medium suction. Adjust the stopcock on the dropping funnel so that the suction will draw the acid *slowly* into the flask. When all the acid is in the flask, fully open the funnel stopcock and pull air through the system at the rate of two or three bubbles per second. After the reaction in the flask has subsided, heat the contents gently to boiling. When steam starts to condense in the condenser, turn off the heat. Continue to draw air through the apparatus for 30 min. Reweigh the absorption tube *G* as before. The gain in weight represents the CO_2 in the sample. Record as C_1.

(*c*) Calculate the weight of CO_2 as follows:

$$C_2 = \frac{C_1}{S}$$

where:

C_2 = grams of CO_2 from the 1-g sample,
C_1 = grams gain in weight of the absorption tube *G*, and
S = grams of sample used.

(*d*) Repeat the procedure on another 1-g portion of the sample and calculate the average value of C_2. The weight of the absorption tube *G* after the first determination may be used as the starting point for the second determination without repeating the initial process of obtaining constant weight.



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Procedure for Asbestos Content by Weight Loss

10. (*a*) Weigh two specimens, not less than 5 g, each representative of each lot or unit sampled. Place the specimens in crucibles which have been previously heated to 800 to 810 C (1470 to 1490 F) for 1 hr, cooled in a desiccator and weighed to the nearest 0.001 g. Dry the specimens to constant weight at 105 to 110 C (220 to 230 F) and record the weight to the nearest 0.001 g. Subtract the weight of the crucible to obtain the oven-dry weight of the specimen.

(*b*) Place the crucibles containing the specimens in the oven and heat for not less than 1 hr at 800 to 810 C (1470 to 1490 F). Remove the specimens from the furnace, and cool in a desiccator to room temperature. Weigh and subtract the weight of the crucible to obtain the weight of the ignited asbestos. Record as *A*.

Calculations

11. (*a*) When carbonates are not present, calculate the asbestos content as follows:

$$\text{Asbestos, per cent} = \frac{\frac{A}{0.86}}{\text{weight of sample}} \times 100$$

where:

A = weight of the sample after ignition, and

0.86 = water of crystallization factor.[3]

NOTE 1.—*If* the asbestos content as determined by the ignition method is lower than expected, the procedure described in Section 9 for determining the amount of CO_2 liberated by carbonates in asbestos may be followed even if the preliminary test for carbonates is negative, and if CO_2 is present the necessary corrections shall be made.

(*b*) When carbonates are present, calculate the asbestos content as follows:

$$\text{Asbestos, per cent} = \frac{\frac{A}{0.86 - C_2}}{\text{weight of sample}} \times 100$$

where:

C_2 = grams of CO_2 from the 1-g sample as determined in Section 9.

(*c*) To calculate the total inorganic content of asbestos textile materials containing continuous filament glass yarns, which were removed prior to test, add the weight of the glass yarn removed from the sample to the numerator and denominator of the equation given in Paragraph (*a*) or (*b*).

NOTE 2.—Where a textile contains asbestos and other inorganic fiber, it may be agreed between the manufacturer and the purchaser that the grade of the textile may be considered as the total amount of inorganic fiber present in the textile, but in all cases the asbestos content shall exceed the amount of other inorganic fiber present.

Report

12. Report the average asbestos content of all specimens tested.

[3] The factor 0.86 is based upon a measured average of 14 per cent water of crystallization in chrysotile asbestos. The asbestos content will be in error to the extent that the weight loss of the asbestos differs from the 14 per cent average. When the asbestos contains carbonates which decompose on heating, the weight loss from the decomposition of the carbonates will be combined with the weight loss from the ignition of the cotton, and an excessive cotton content will be indicated. This may result in an erroneous classification of the material to a lower grade.

NOTE: ASTM Specifications and Methods of Test are subject to continual revision. Consult the Society's current "ASTM Standards on Textile Materials" for possible changes in this specification.

APPENDIX

DESCRIPTION OF APPARATUS

A1. *Knorr Alkalimeter*, consisting of the following parts connected as shown in Fig. 1:

(*a*) *Gas Washing Bottle, A*, containing concentrated H_2SO_4 which serves both to indicate the rate of gas flow and to prevent any water vapor entering the system from the atmosphere.

(*b*) *Drying Tube or Cylinder, B*, filled two-thirds full of soda-asbestos absorbent (Ascarite) and one-third full of a drying agent to remove all CO_2 from the air.

(*c*) *Knorr Alkalimeter Unit, C*, which consists of a dropping funnel, a distillation flask, and a condenser fitted with standard-taper joints to form a unit assembly.

(*d*) *Gas Washing Bottle, D*, containing a solution of 5 to 10 per cent by weight of Ag_2SO_4 in concentrated H_2SO_4. This serves to absorb any water vapor that escapes from the condenser and to remove any HCl from the evolved gases.

(*e*) *Drying Tube, E*, containing $CuSO_4$ to absorb any H_2S generated by the absorption of HCl.

(*f*) *Drying Tube, F*, filled with a suitable drying agent to effect complete drying.

(*g*) *Absorption Tube, G*, filled two-thirds full of soda-asbestos absorbent (Ascarite) and one-third full of a drying agent, to absorb the CO_2.

(*h*) *Absorption Tube, H*, filled with a drying agent and soda-asbestos absorbent (Ascarite) in the reverse direction to prevent CO_2 from entering the system.

(*i*) *Trap, I*, to prevent back flow of water from the aspirator.

(*j*) *Valve or Pinched Tubing, J*, to control the rate of air flow pulled through the system by the aspirator.

A Glossary of Asbestos Textile Terms

ABRASION RESISTANCE—The degree to which a fabric is able to withstand surface wear and rubbing.

ASBESTOS. CHRYSOTILE—A hydrated silicate of magnesium.

BLENDING—The combining of asbestos fibers of different types, grades or staple length prior to spinning in order to produce a desired and uniform end result.

BRAID—A narrow textile band formed by plaiting together several strands of asbestos yarn.

CALENDERING—A finishing process for fabrics which produces a flat, shiny, smooth surface. It is obtained by passing the cloth through hollow heated calender rolls.

CARDING—A process of opening and cleaning textile fibers which separates them from each other, lays them parallel, makes them into a thin web and condenses them into a continuous, untwisted strand of fibers called a "sliver." This process removes most of the impurities.

CLOTH, DOUBLE—A fabric produced by weaving two cloths, one above the other, on the same loom and binding them together by binder yarns during the weaving operation.

CLOTH, LISTING—Little used term to designate narrow fabrics or tapes.

CLOTH, METALLIC—A woven fabric of metallic (wire-inserted) asbestos yarn.

CLOTH, PLAIN—A woven fabric of plain (non-metallic) asbestos yarn.

CLOTH, TREATED—Asbestos cloth impregnated or coated with an organic resin or inorganic compound.

CONE, PAPER—A conical-shaped core for a yarn package.

CORD, BRAIDED—The product formed by braiding a jacket over a core of yarns or other braids.

CORD, TWISTED—The product formed by tightly twisting together two or more plied yarns.

COUNT OF CLOTH—The number of yarns (or threads) per inch.

CUT, ASBESTOS—Unit of yarn measurement used in the asbestos yarn numbering system. It is the number of 100 yard lengths per pound. For single yarns, the number of yards per pound is obtained by multiplying the cut number by 100. For plied yarns, the number of

yards per pound is obtained by multiplying the cut number by 100 and then dividing by the number of plies. The latter value is then reduced slightly for twist contraction by multiplying by a twist contraction factor to give the yards per pound in the plied yarns.

END—An individual warp yarn.

FABRIC COUNT—The number of warp ends and filling picks per inch in a woven fabric; also called texture, thread count, pick count.

FABRIC, SLIT—A narrow material or tape, without selvage, cut from a wide piece of woven fabric.

FELT, ASBESTOS DRYER—A woven multiple layer fabric serving as a conveyor belting which carries the moisture-laden paper through the dryer section of a papermaking machine.

FELT, NON-WOVEN—An asbestos product in sheet formation produced by carding or other fiber orienting process.

FIBER, CARDED—Asbestos fiber which has been finely divided by carding.

FILAMENT—The single individual fiber of indefinite length, such as filament rayon, nylon, polyester, etc.

FILLING—See WEFT.

GAUGE OR GAGE—The thickness of a woven fabric.

GRAB TEST—Testing of fabrics for strength by a controlled method in which the test is made on a machine, the important features of which are two metal jaws that grip and pull the fabric until it is ruptured.

HERRINGBONE TWILL—A broken twill weave giving a zigzag effect produced by alternating the direction of the twill.

LAP—A carded assemblage of asbestos fibers in roll form.

PICK—An individual filling yarn.

PLAIN WEAVE—The most common of the fundamental weaves. Each filling yarn passes successively over and under each warp yarn, alternating each row.

ROPE, BRAIDED—The product formed by braiding one or more jackets over a core of asbestos rope or wick, by braiding asbestos yarn braid over braid, or by plaiting asbestos yarn into square cross-section.

ROPE, TWISTED—The product formed by tightly twisting together two or more strands of asbestos wick.

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GLOSSARY—Cont'd

ROVING, PLAIN—An assemblage of asbestos or asbestos and other fiber condensed into a strand with no twist as delivered from an asbestos carding process.

ROVING, REINFORCED—As asbestos roving into which a core yarn other than asbestos has been inserted to increase the roving strength.

SELVAGE OR SELVEDGE—Special yarns woven on the extreme outside edge of a woven fabric for the purpose of reinforcement.

SLIVER, ASBESTOS—A loose, bulky, rope-like form, without twist, delivered from a carding process; produced in various weights per yard.

SPINNING—Process of drawing and twisting fibers together to produce thread or yarn.

STAPLE—Term describing the average length of any fiber.

TAPE, METALLIC—A narrow woven fabric of metallic (wire-inserted) yarn with selvage edges.

TAPE, PLAIN—A narrow woven fabric of plain (non-metallic) yarn with selvage edges.

THREAD—A treated yarn having high tensile, uniformity and smooth finish.

TUBE, PAPER—A paper cylinder used as a core for a yarn package.

TUBING—Woven, knitted or braided fabrics of cylindrical form.

TWILL—The second basic weave. It has a distinct diagonal line due to warp yarns passing over one or more filling yarns, then under two or more, or vice versa.

TWIST—The number of times one inch of yarn is twisted.

TWIST, "S"—A yarn or cord has "S" twist if the spirals conform in the direction of slope to the center section of the letter "s".



TWIST, "Z"—A yarn or cord has "Z" twist if the spirals conform in the direction of slope to the center section of the letter "z".



WARP—The yarn running lengthwise in a woven fabric.

WEAVING—Process of forming a fabric on a loom by interlacing the warp and filling threads with each other. The fundamental weaves are plain, twill and satin. All other weaves, no matter how intricate, employ one of these basic weaves in their composition.

WEFT—The yarn running crosswise in a woven fabric, or at right angles to the warp threads. Weft is the present English name. Very old term was "woof." American term is "filling" (or yarn that fills in).

WICK—A soft pliable asbestos textile product formed by loosely twisting several strands of roving or slubbing.

YARN—The product of spinning. Asbestos yarns are continuous strands of spun fibers which are cleaned, drawn and made into yarn by a twisting operation on a spinning frame.

YARN, BINDER—A warp thread in multiple ply cloths which binds several pieces of cloth together.

YARN, CABLED—A twisted product of multiple ends of plied yarn.

YARN, CORE—A reinforced asbestos yarn in which the reinforcing medium is centered in and covered by the outer material.

YARN, CORNERING OR SQUARING—Those yarns used in braiding to form the corners for square braids.

YARN, GANG SPUN—Two or more strands (plain or reinforced) of asbestos rovings combined in a spinning operation.

YARN, KNOTLESS—A continuous length of yarn made from two or more pieces joined together by splicing or a suitable adhesive.

YARN, METALLIC—One of more ends of single asbestos yarn twisted together with one or more strands of fine wire.

YARN, PLAIN—Yarn, either single or plied, which consists of asbestos fiber or asbestos and other fibers.

YARN, PLIED—A yarn product produced by twisting together two or more ends of single asbestos yarns.

YARN, REINFORCED—Yarn, either single or plied, with an insert of yarn other than asbestos to give the product higher tensile strength; sometimes referred to as inserted yarn.

YARN, SINGLE—A single roving, twisted to give it tensile strength.

YARN, SIZED—See YARN, TREATED.

YARN, STUFFER—An extra yarn used to give weight or bulk to a multi-layer fabric. Yarn can be either warp or filling and lies between the face and back of the fabric and does not interweave with the fabric.

YARN, TREATED—A yarn coated or impregnated with compounds to lay the fibers, increase tensile strength, or impart other properties.

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