Handbook of

ASBESTOS TEXTILES

SECOND EDITION



ASBESTOS TEXTILE INSTITUTE

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FOREWORD

THE ASBESTOS TEXTILE INSTITUTE is a non-profit organization of manufacturers of asbestos textile products and producers of asbestos fibers. One of its primary aims is the development, through a continuous program of research and practical testing, of improved quality standards in the various products made by its members. It also serves as a clearing house for the dissemination of useful information relating to asbestos textiles and their applications.

This Handbook contains data which it is hoped will prove helpful to users and others who may benefit from knowing about asbestos textiles and their adaptability to numerous industrial requirements. The Institute is indebted to the Quebec Asbestos Mining Association for invaluable technical assistance in the preparation of tables and text; it is also grateful to the American Society for Testing Materials for permission to reproduce the specifications and test methods for asbestos textiles.

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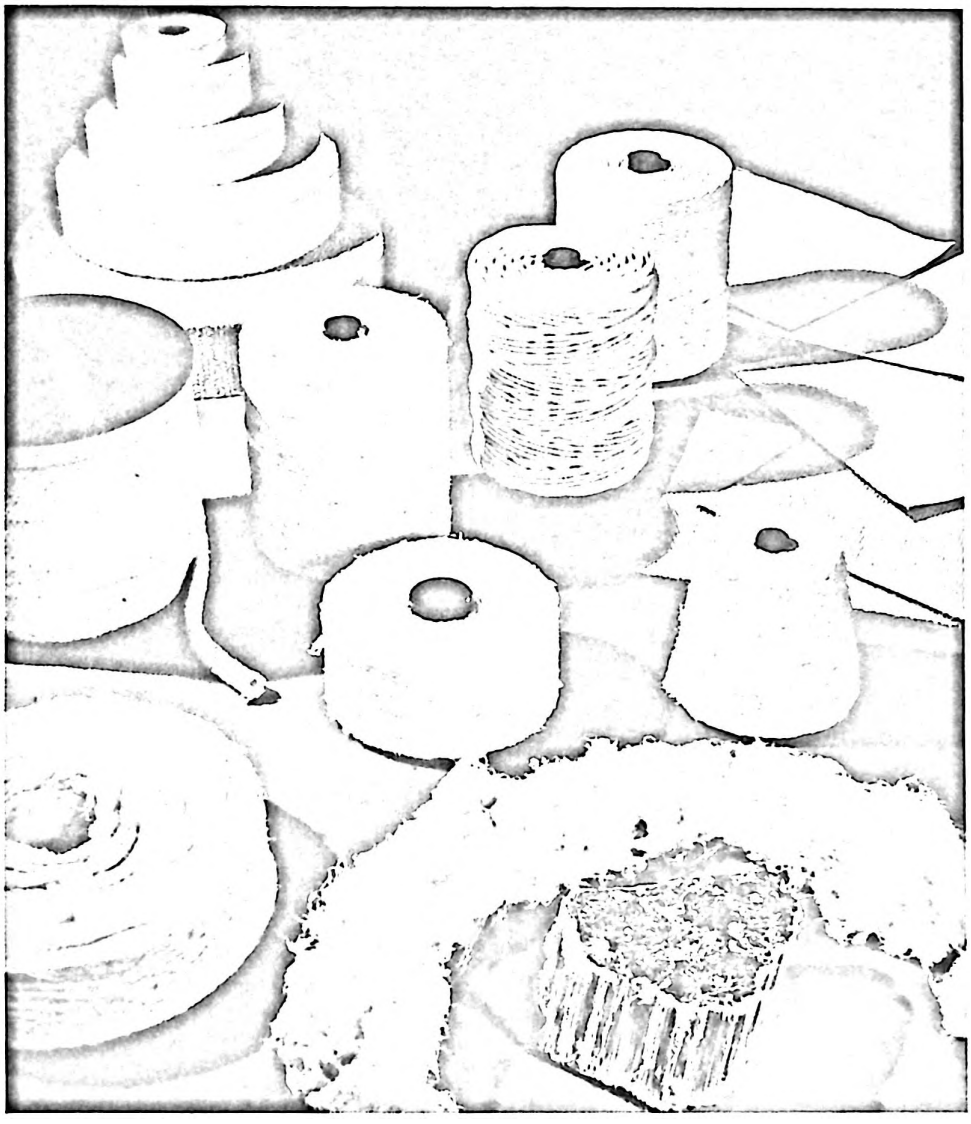
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From the mineral asbestos, hard and rocklike in structure, come the soft, silky fibers that are made into many forms of textile products

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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 may be 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.

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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 occur in different forms in many countries throughout the world. The word is derived from the ancient Greek language and its first recorded use was by the Roman naturalist, Pliny the Elder, in the first century A. D., although asbestos itself was known to the Greeks and used by them at an even earlier date.

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

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

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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

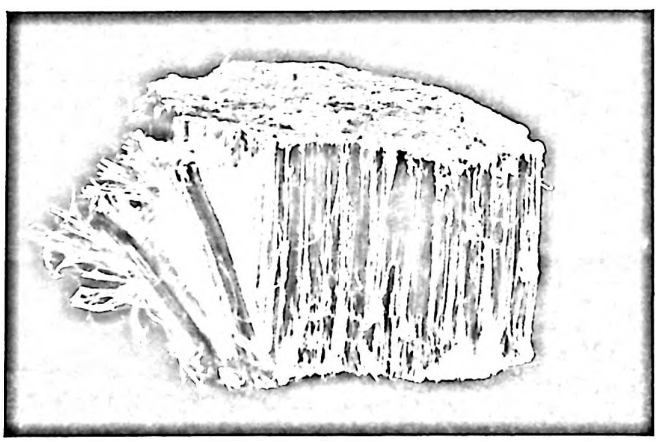
The commercial value of asbestos depends largely on two physical characteristics—its incombustibility and its unique fibrous structure. The latter permits it to be separated into filaments or fibers, many of which possess high tensile strength and unusual flexibility and are adaptable to numerous uses. 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

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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 $Mg_3Si_2O_5(OH)_4$ or a multiple thereof to show the actual state of the water in the structure.[2]

Origin: Almost all of the world's resources of chrysotile asbestos are associated with ultrabasic rocks, or those igneous rocks, composed essentially of magnesian silicate, which were injected upward into the earth's crust. Where adjustments in the crust later produced faulting and the formation of closely spaced fractures, and hydrothermal solutions, probably of a siliceous character, were permitted to circulate, the adjacent host rocks were subjected to serpentinization, or the conversion of anhydrous to hydrous magnesian silicate.

The actual manner in which chrysotile asbestos was formed is a matter of conjecture. One hypothesis put forward is that during this process of serpentinization, in some instances, the fracture walls were converted to, and the fracture openings were filled with, a colloidal serpentine-gel, the magnesia and part of the silica of which were derived from the adjacent enclosing rock. Through loss of water this gel then is presumed to have congealed to produce an amorphous serpentine which in turn crystallized into fibrous aggregates of chrysotile asbestos to form asbestos veins. Iron released during the process of serpentinization was deposited as magnetite.

Nature, however, 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 may also be 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.

---

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

[2] The chemical formula of chrysotile has heretofore been variously expressed as $H_4Mg_3Si_2O_9$ and $(OH)_8Mg_6Si_4O_{11}.H_2O$.

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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 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.

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.

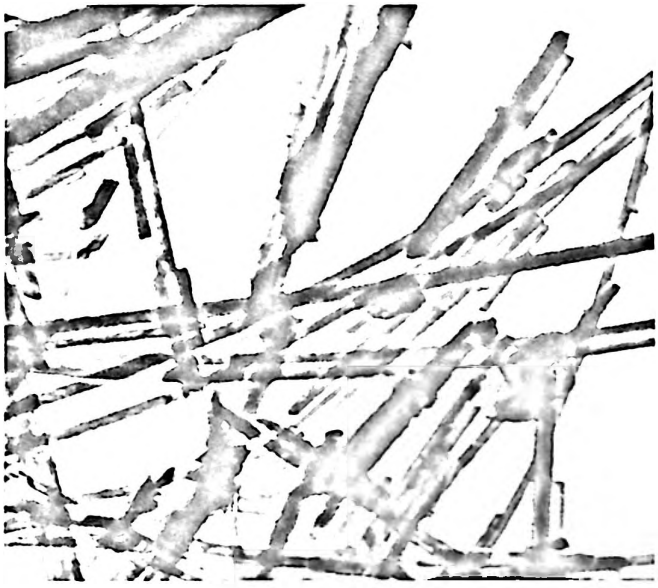
Recent studies under the electron microscope indicate that the chrysotile fiber may be tubular in structure. The unique hydrous characteristics exhibited by chrysotile would seem to bear this out.

The better grades of chrysotile are characterized by their extreme fineness or silkiness which, together with their exceptional flexibility and high tensile strength, results in superior spinnability. Chrysotile asbestos may be subdivided into ultimate fibrils so fine that they are revealed only with an electron microscope. The diameters of these individual 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.

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. When harshness is accompanied by brittleness the fiber may be unsuitable for textile processing. These objectionable properties may be found in

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Chrysotile asbestos fibers as seen under the electron microscope at 41,200 magnifications

chrysotile derived from both igneous and sedimentary formations—in massive serpentine or in the thin serpentine of altered limestone. 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 Ontario and British Columbia. Canadian output amounted to 1,061,400 short tons in 1957[3], a major portion of the total 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.

[3] G. F. Jenkins, Industrial Minerals and Rocks, Third Edition, 1960.

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Other important suppliers of chrysotile fiber include Southern Rhodesia, which produced approximately 132,000 short tons in 1957[4], and the United States, with a production of 43,700[4] short tons during the same year. The "soft" variety of Arizona fiber is particularly suitable for electrical insulation but little has been available in recent years.

Italy and Swaziland rank next to the United States as sources of chrysotile fiber, with yearly production amounting to more than 30,000 short tons in both countries. Recently, chrysotile has been found in other areas, including Turkey, Venezuela and Colombia. Large deposits are being mined in Russia.

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 and sodium corresponding approximately to the chemical formula $Na_2Fe_5Si_8O_{22}(OH)_2$. Its composition, like that of chrysotile is found to vary[5].

Crocidolite is more difficult to process into a spinnable fiber than chrysotile, although some yarns and other textile products are made of this fiber. 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 75,000 short tons in 1957[4]. 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—$(FeMg)_6Si_8O_{22}(OH)_2$—is essentially a ferrous silicate in which a proportion of the iron is replaced by magnesium[6]. The ratio of magnesium to iron may vary somewhat 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 but because of their relative harshness they are not well adapted to spinning.

[4] G. F. Jenkins, Industrial Minerals and Rocks, Third Edition, 1960.
[5] The chemical formula of crocidolite is also expressed as $Na_2O\ 3FeO\ Fe_2O_3\ 8SiO_2\ H_2O$.
[6] The chemical formula of amosite is also expressed as $1.5MgO\ 5.5FeO\ 8SiO_2\ H_2O$.

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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 57,000 short tons were produced there in 1957[4].

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 $(Fe.Mg)_7 Si_8O_{22}(OH)_2$. 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—$CA_2Mg_5Si_8O_{22}(OH)_2$—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—$(Ca.Mg.Fe)_6Si_8O_{22}(OH)_2$—is similar in composition to tremolite except for the presence of iron which replaces some of the magnesium. Like tremolite, 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
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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.†	16,000 to 90,000	4,000 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)

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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

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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)

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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
Ramie	0.000985	1,015
Wool	0.0008 to 0.0011	910 to 1,250
Cotton	0.0004	2,500
Rayon	0.0003	3,300
Nylon	0.0003	3,300
Glass	0.00026	3,840
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

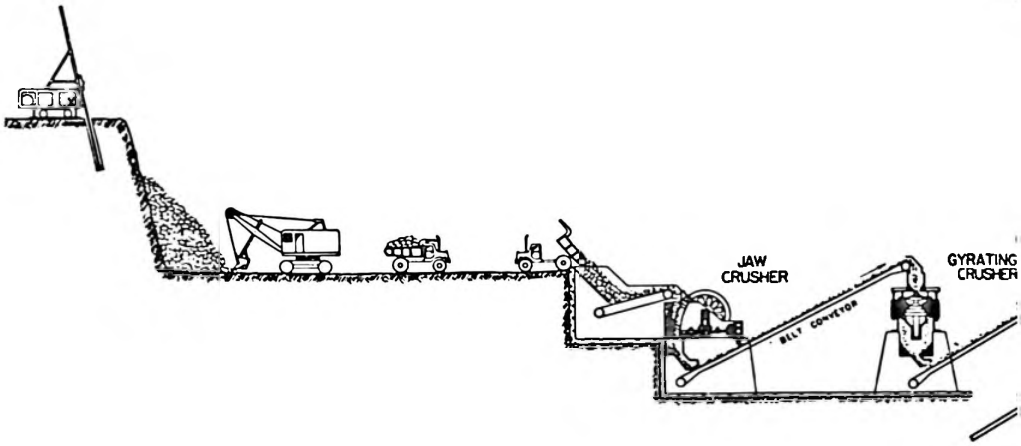
*Canadian Mining and Metallurgical Bulletin, April, 1951

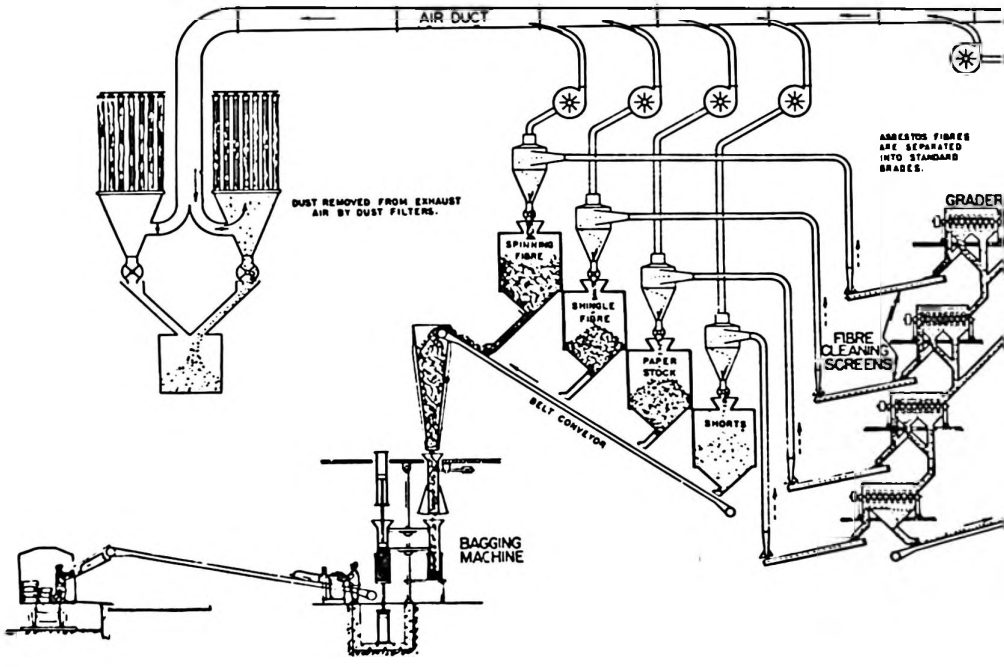
TABLE J—COMBUSTION ANALYSIS OF CHRYSOTILE ASBESTOS*

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

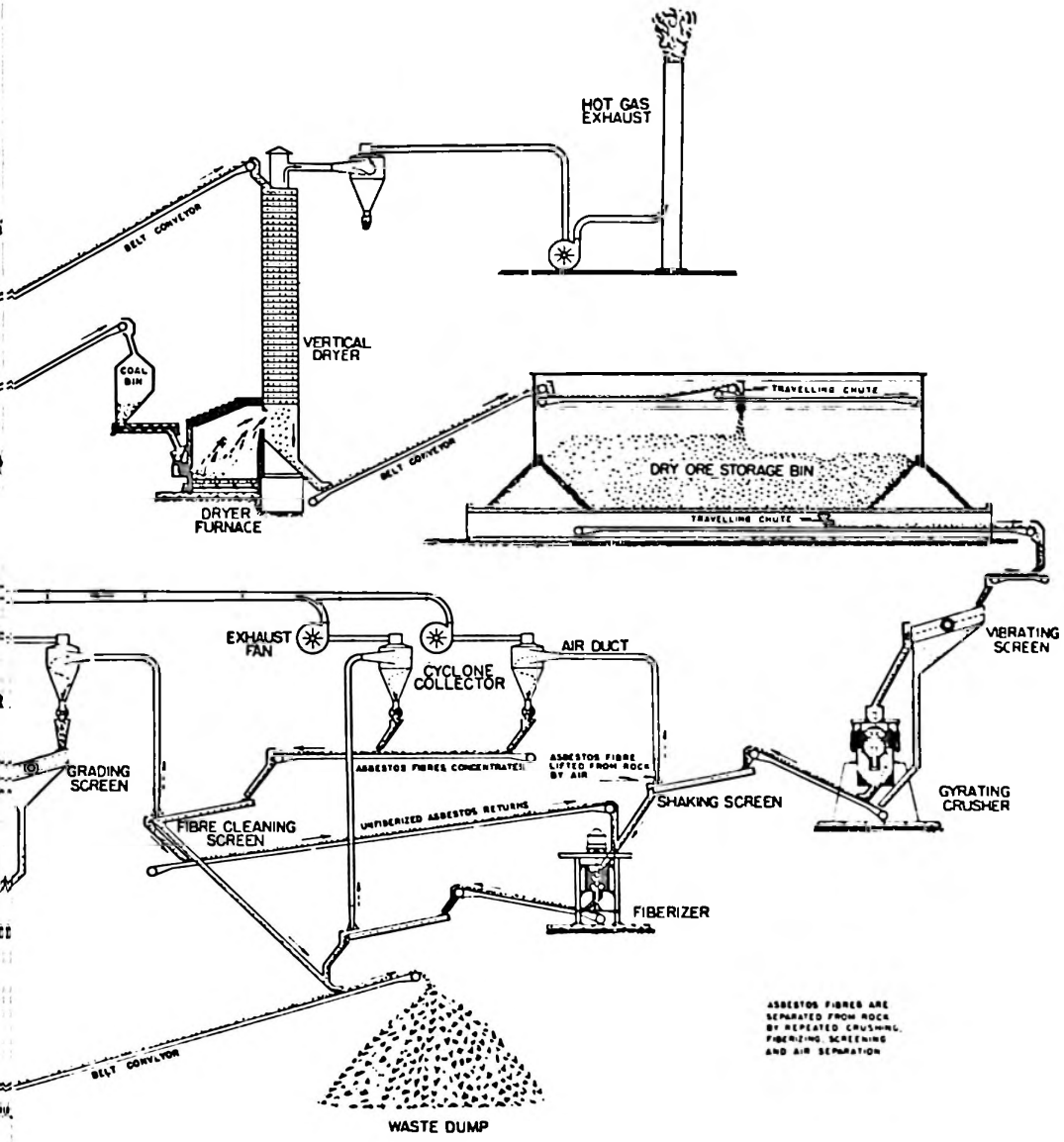
*Canadian Mining and Metallurgical Bulletin, April, 1951

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Flowsheet of a typical asbestos mine and mill

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

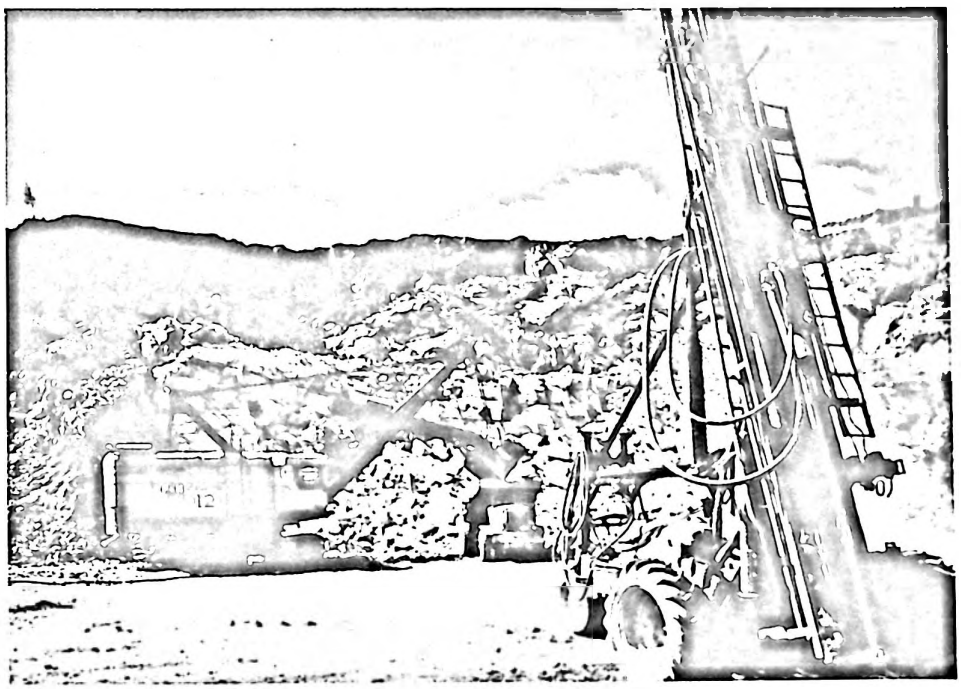
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The Mining, Milling and Grading of Asbestos Fibers

Because asbestos is found both on or near the earth's surface as well as at considerable depths below it, various methods are used for extracting the ore. Either open pit or underground mining may be employed, depending on the character of the deposit and also on the extent to which it has been exploited.

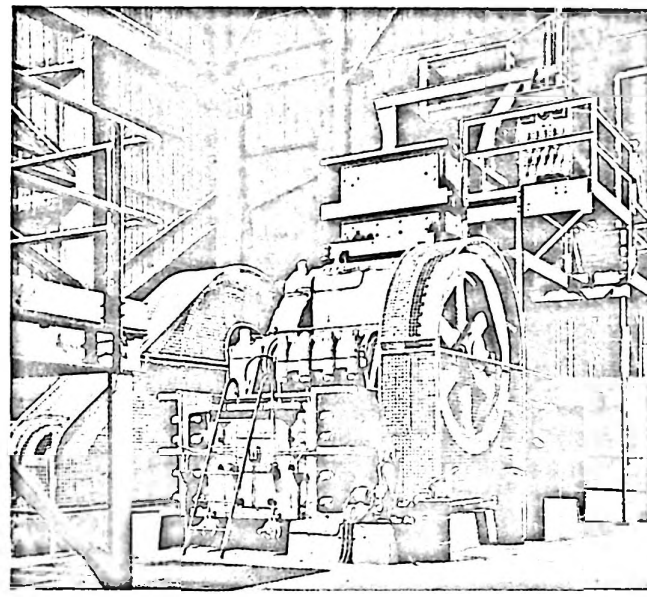
In the past, most of the Canadian chrysotile, which is the principal source of the fiber used for processing asbestos textiles in the United States, has been removed from open pits. After holes have been drilled into the face of the deposit with compressed air drills the fiber-bearing rock is loosened by blasting. Following a rough separation of ore and barren rock in the pit, the ore is transported to the mill by trucks, into which it is loaded by power shovels.

In recent years, as some of the open pits have become worked to the economic limit, it has been necessary to use other methods. Consequently, underground mining, similar to that used in the removal of coal and other minerals, has been introduced. In one method, known as block caving,



An open pit asbestos mine

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

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. See page 17.

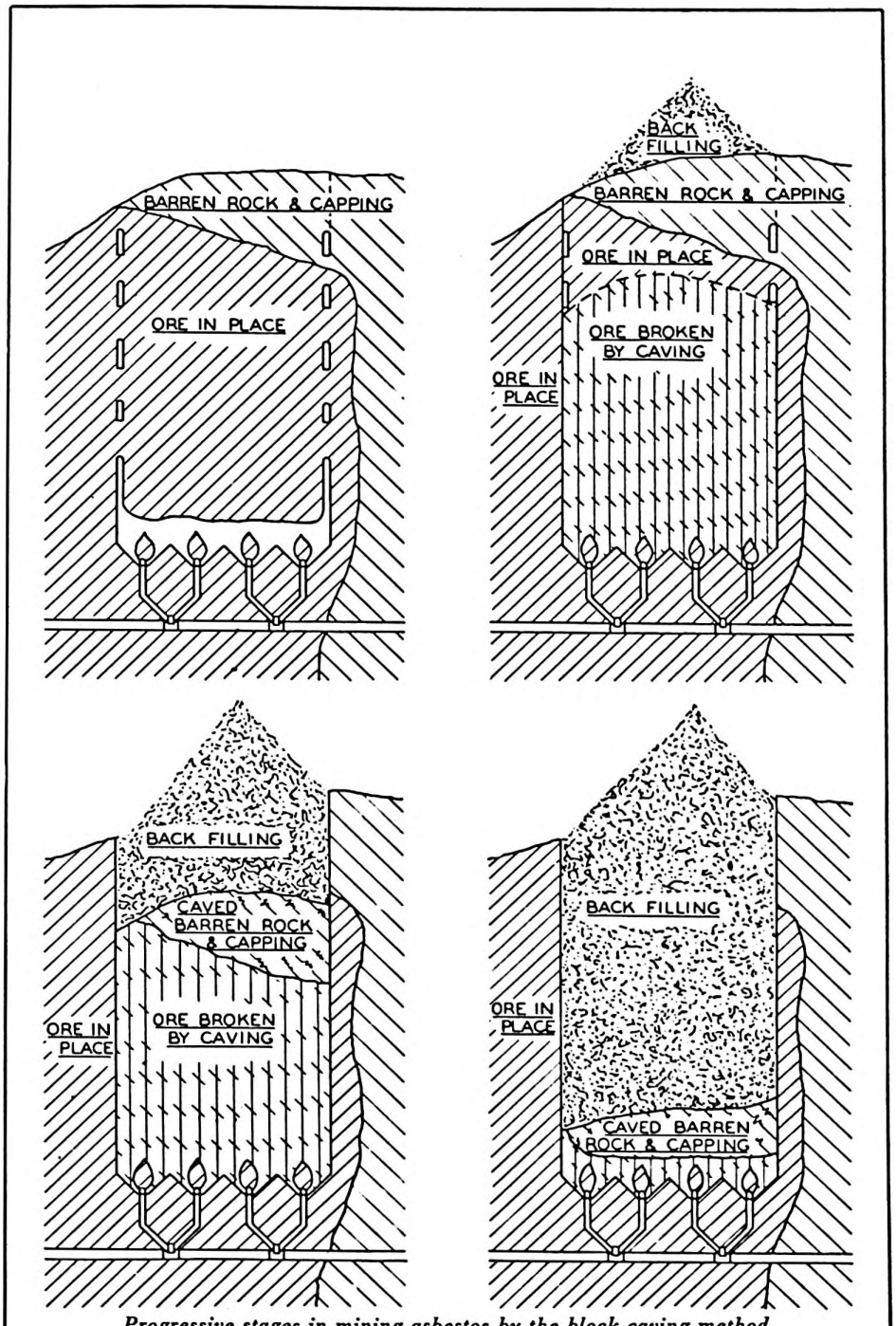
The percentage of fiber recovered from the ore is relatively small, the yield from Canadian mines ranging from three to twelve percent depending upon the locale and the desired objectives of the operations. This means that from eight to thirty tons of asbestos-bearing rock must be mined in order to produce a single ton of usable fiber, most of which, however, is of insufficient length for spinning. Of the total tonnage of asbestos fiber extracted from the mines of the world in recent years, only about three to four percent consists of grades that are 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.

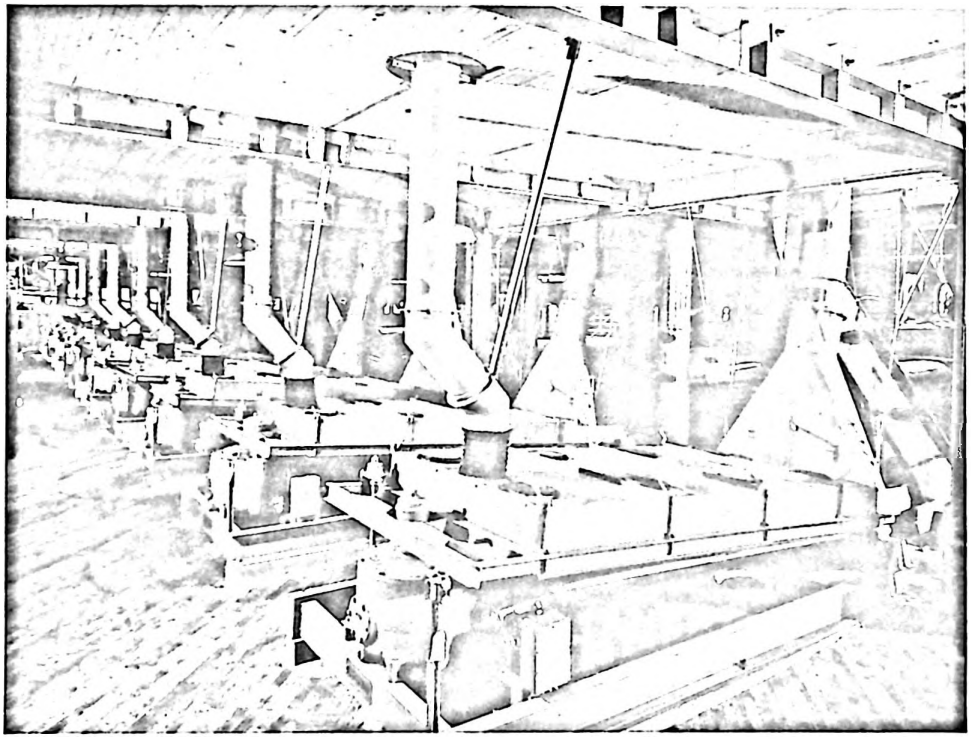
Enormous jaw crushers, some with a capacity of more than 250 tons of ore per hour, are used for the primary crushing. Secondary crushers, usually

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Progressive stages in mining asbestos by the block caving method

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

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.

Following each of these operations, a rough 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.

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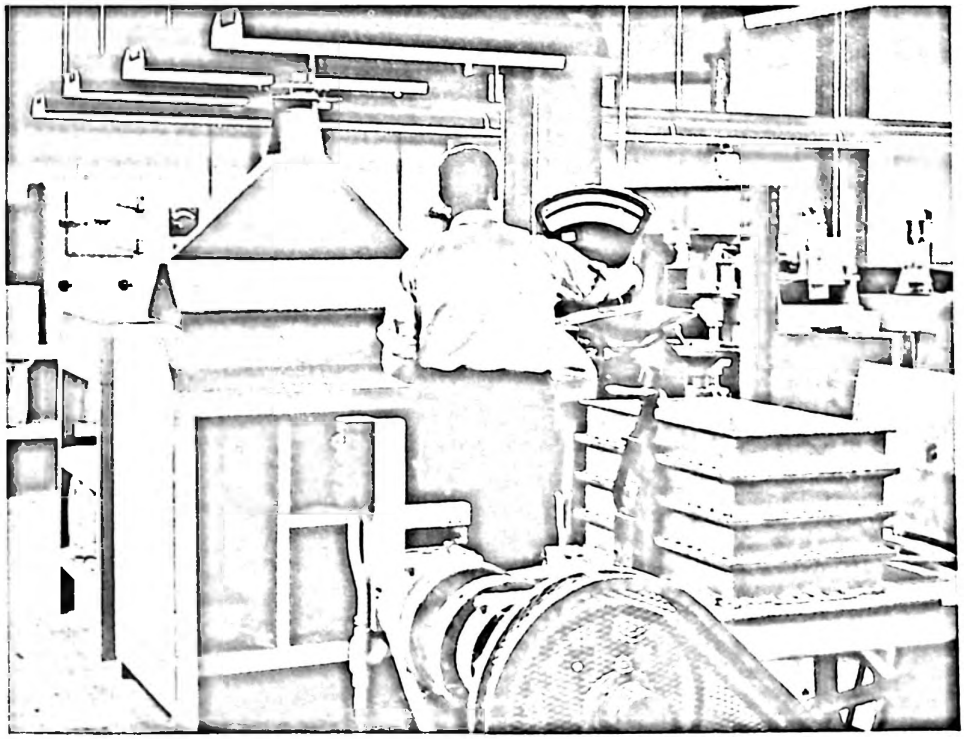
COBBING

A small percentage of textile fibers (those ranging in length from 3/8" to 3/4" 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



Test laboratory showing screening equipment for making the Quebec Standard Screen Test

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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, the Clark Classifier and the Modified Suter-Webb Cotton Sorter.

TEXTILE GRADES

Canadian Chrysotile: Only the longest, costliest 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"

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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

Note: Canadian 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.

African Chrysotile: The Southern Rhodesian grades of milled fiber are as follows:

C&G/1—a textile fiber equivalent to Canadian Crude No. 2
C&G/2—a textile fiber equivalent to Canadian 3K

Milled fibers from the Havelock mine in Swaziland are graded as follows:

HVL/1—long spinning fiber
HVL/2—short spinning fiber

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	1¼" to 1¾"
D	Over 1¾"

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

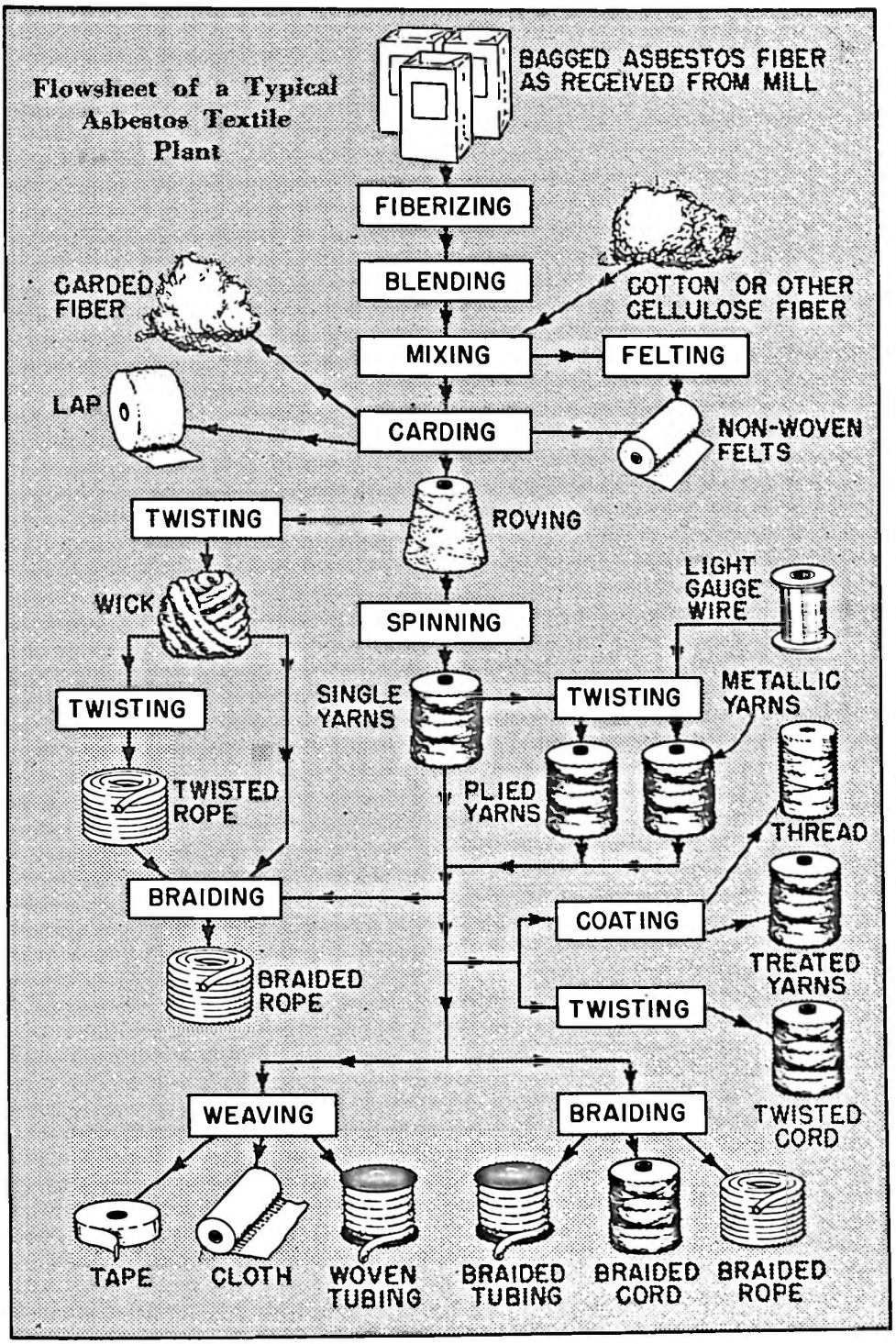
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Amosite: For the same reason as stated under "Crocidolite" above, amosite is also supplied in a semi-milled condition and classified on the basis of length of fiber in the seams or unmilled cobs from which the various grades are obtained. Control of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

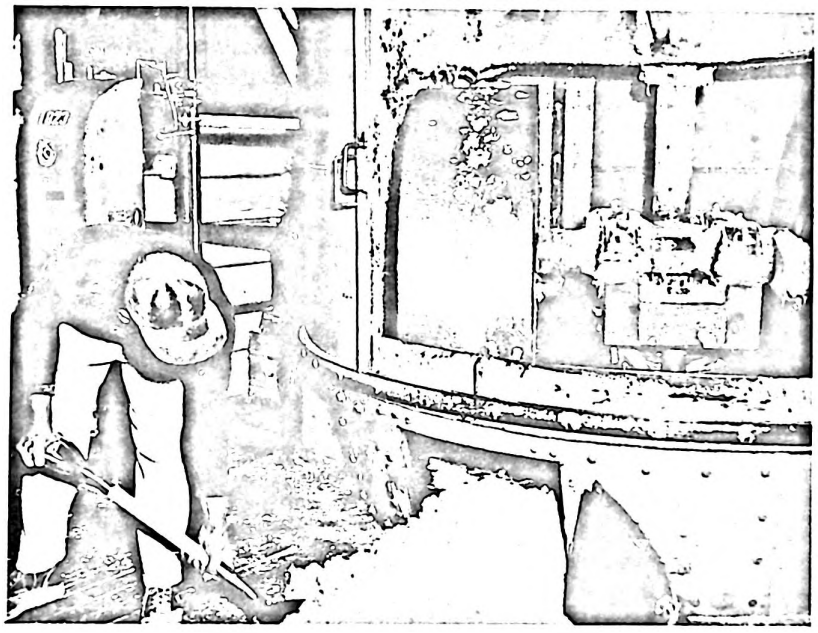
Fibers from the various mining properties in the Transvaal are graded as shown below:

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
S3	⅛" to ¾"	Shorts (part fiberized)	Gray

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A chaser mill in operation. Here the crude asbestos fibers undergo preliminary opening

Processing Asbestos Textiles

As previously noted, the asbestos fibers as received at the textile plant are of two types with respect to the extent of fiberization obtained at the asbestos mill. Milled fibers, which constitute the largest proportion of fibers used in textiles, are in a semi-opened condition. Crude or unmilled fibers are in the form of small unopened bundles. The fiberizing process consists of several operations, each of which brings about additional subdivisions of the fibers until the desired degree of separation is eventually attained.

FIBERIZATION

After the bags of fiber have been inspected for quality, the crude fibers undergo preliminary opening. This is usually done in a pan crusher or chaser mill, the fibers passing under heavy steel or granite wheels with flat faces. Separated impurities are then removed by screening.

Milled fibers usually do not require this preliminary chaser mill treatment but may be passed through a vertical opener or a rotating toothed cylinder known as a willow that effects finer fiberization.

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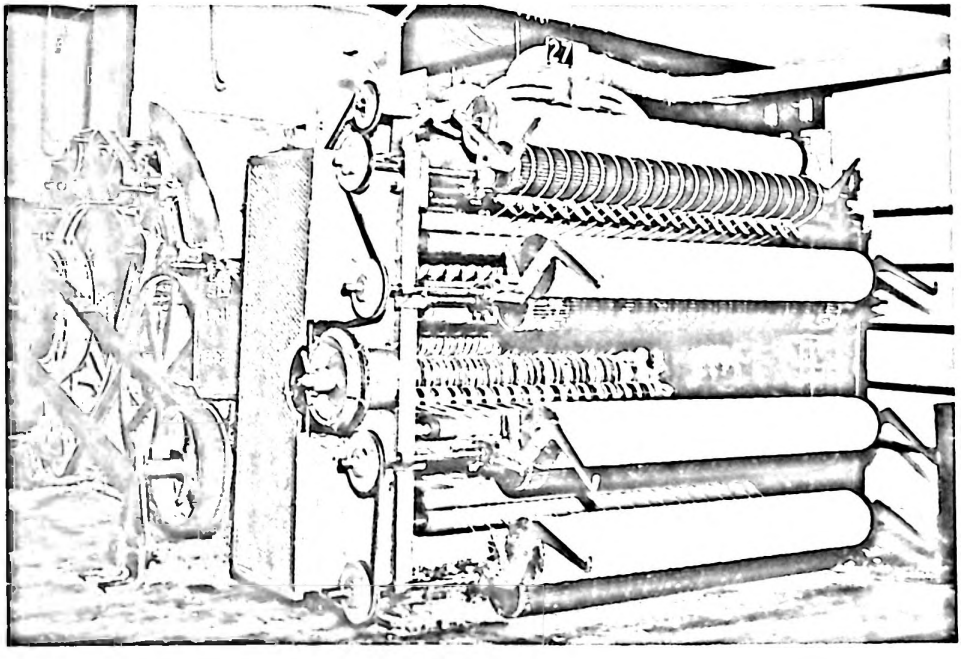
After additional treatment by means of specially designed opening equipment and further screening to remove fibers too short for textile purposes, the fibers are ready for the blending and mixing processes.

BLENDING AND MIXING

To obtain such desired characteristics as tensile strength and uniformity in the finished product, different types or grades of asbestos fibers are carefully blended at this point. Small percentages of organic fibers such as cotton or rayon (up to 25%) may then be added as carriers or supporting agents to improve spinning properties and to impart the desired serviceability in the specific end product. The latter operation is known as mixing.

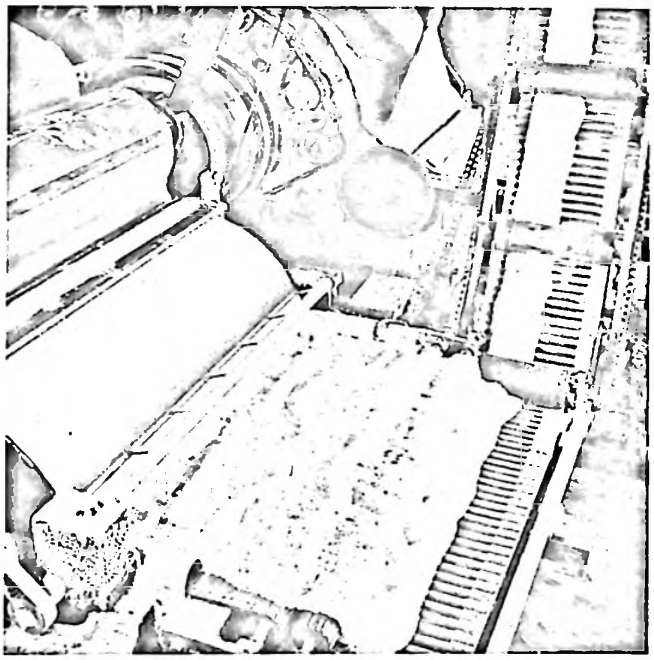
CARDING

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



An asbestos carding machine showing roving being wound on jack spools

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

ribbons, rubbed mechanically and condensed into untwisted strands. Roving is the asbestos textile product from which yarns are produced.

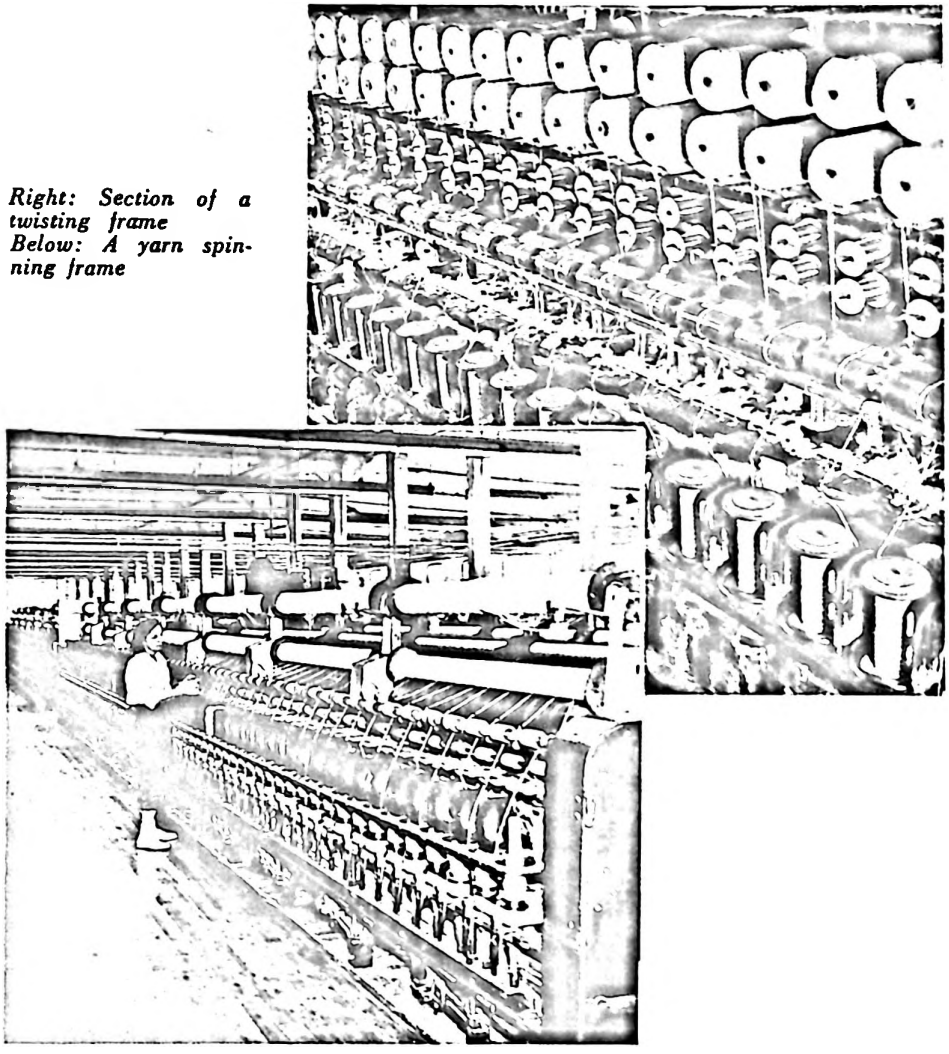
SPINNING, TWISTING AND FORMING

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.

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Right: Section of a twisting frame
Below: A yarn spinning frame

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 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

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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

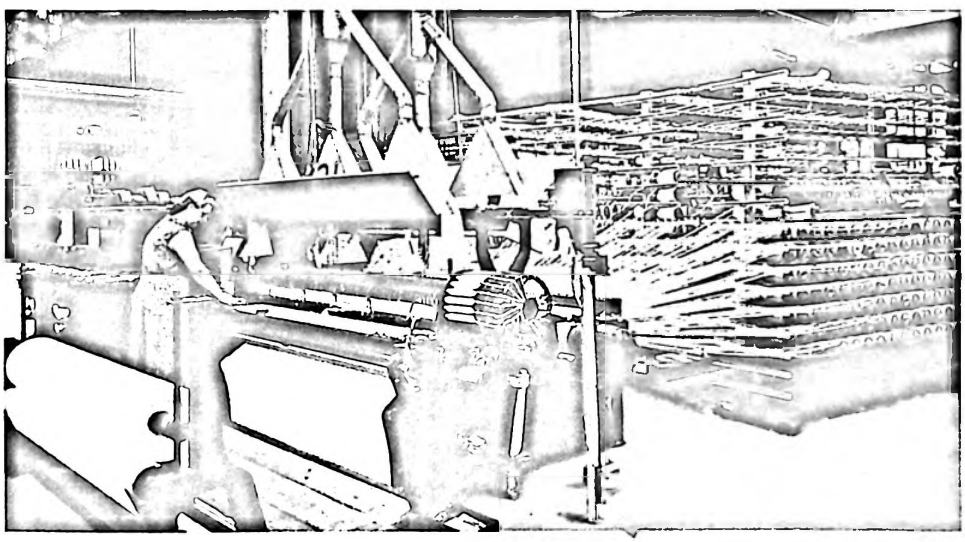
The braiding process is done from a series of yarn-carrying spindles, half of which travel in one direction and half in the opposite direction. The action is similar to that in a maypole dance, the yarns being plaited together to form a braided product. Many kinds of braids, both round and square, may 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 well-opened asbestos fibers or a mixture of asbestos and other fibers to produce a uniform and continuous nonwoven sheet. The fibers may have random or parallel orientation and special binders may be added to provide fabrication strength or other desired properties.

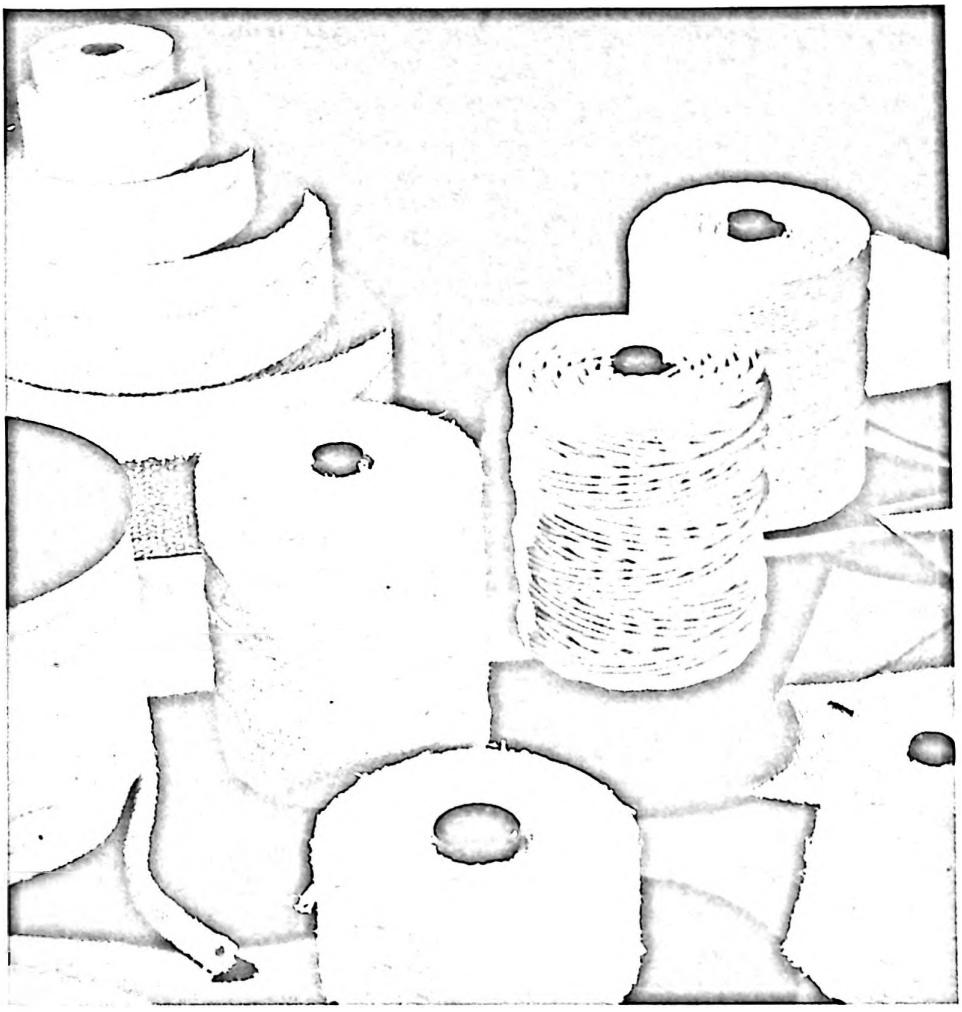
INSPECTION AND QUALITY CONTROL

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

On the following pages is presented information about the various products made from asbestos fibers by the American asbestos textile industry. This includes a brief description of each product and how it is made, together with pertinent data relating to styles, sizes, weights, etc., and a list of uses. It should be understood that the latter is by no means complete in most cases. The uses given are merely intended to convey some idea of the general type of service for which each product is best adapted. 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.

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

As Established by the American Society for Testing 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%

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.

The grade most satisfactory for a given purpose is largely dependent on service temperatures (see below).

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 1500° F), but also, in more recent applications, where temperatures in excess of 5000° F may be encountered.

Plain (non-metallic) Asbestos Textiles—through 900° F: There are two inherent 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

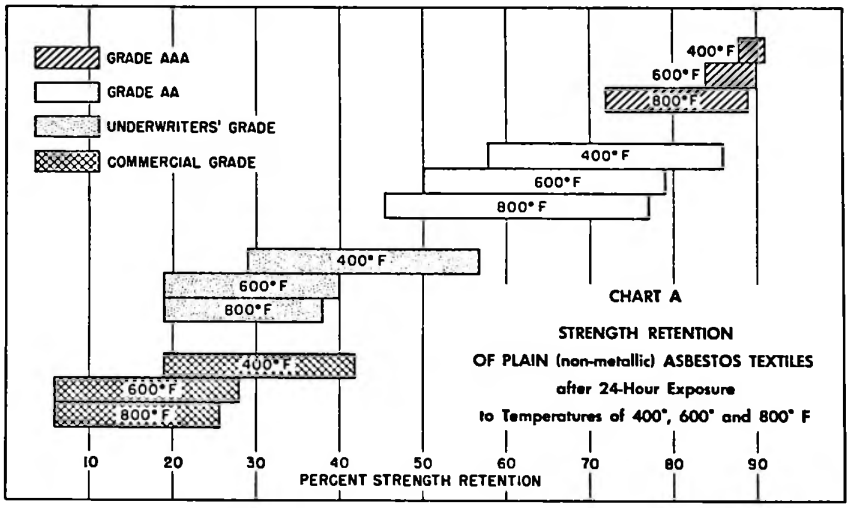
Resistance to degradation by heat is largely a function of the asbestos content: the higher the percentage of asbestos fiber, the higher the serviceability at elevated temperatures. Design and construction, however, also influence high temperature serviceability. In general, those textiles which are 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.

[1]See A.S.T.M. Specification D 299, reproduced on pages 64 to 68, for the test methods used to determine grades.

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Chart A shows the results of 400° to 800° 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 percent-



ages 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 abrasion resistance and higher thermal conductivity.

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 in-

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clude 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, recent studies show 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 1/8" 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 1/8" thick phenolic resin impregnated asbestos felt. At the 5000° F operating temperature, this 1/8" 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 serviceable at temperatures above 3000° F and are lighter in weight and will withstand more physical abuse than conventional ceramic products.

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Carded Asbestos Fiber

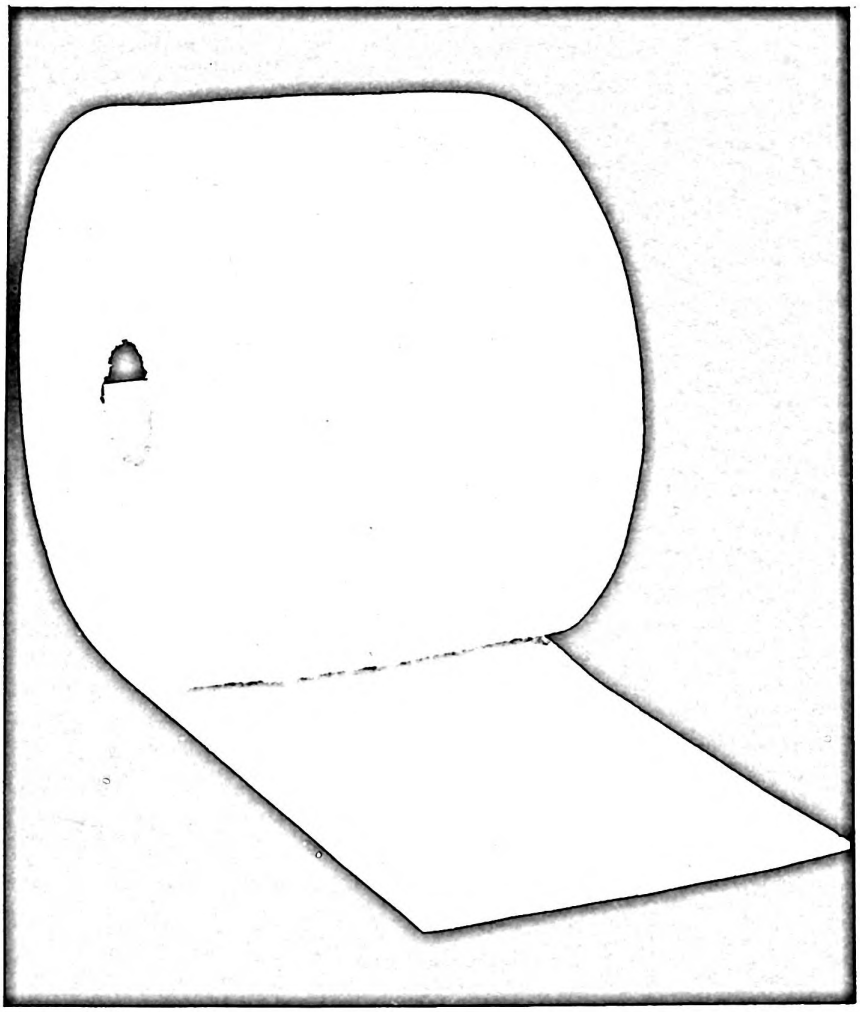
CARDED asbestos fiber is 100% asbestos which has been fiberized by passing the crude through the several operations of the fiberizing process and by screening and carding. It is furnished in various qualities which are determined by the fiber length and type of crude asbestos used and by the operations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

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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 formaton 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 fibers which serve as a carrier for the electrical insulating compounds. The employment of asbestos to completely envelop certain types of copper wires which may

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be exposed to severe heat has long been a requirement of the National Electrical Code in the interest of preventing electrical fires.

Grades, Weights: Asbestos lap is made in the following standard A.S.-T.M. grades: Underwriters', A, AA and AAA. (See Table K for percentage of asbestos content in each grade.) It is supplied in unit rolls ranging from 250 to 4200 grains[2] per linear yard.[3]

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

Type 2—Magnetic Rating 0.75 Maximum
Type 4—Magnetic Rating 2.00 Maximum
Type 6—Magnetic Rating 4.00 Maximum

Type 2 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 4 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 6 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.

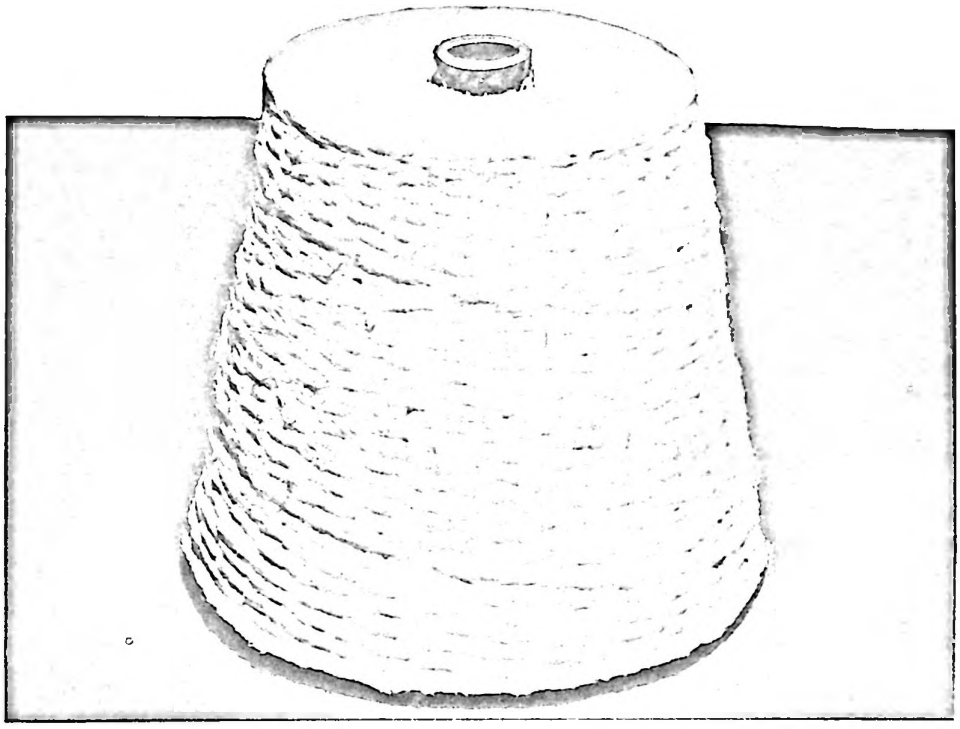
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[2]Grain: a unit of weight. 7000 grains = 1 pound.

[3]For permissible weight variations, methods of test and other detailed information about asbestos lap not given above, see A.S.T.M. Specification D 1061, reproduced on pages 58 to 60 of this handbook.

[4]See A.S.T.M. Specification D1118, page 76.

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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 A.S.T.M. grades: Underwriters', A, AA, AAA and AAAA. (See Table K 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

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yards per pound. Standard cut numbers, with nominal yards per pound and permissible variations are shown in Table 1, A.S.T.M. Specification D 375 reproduced on page 62.

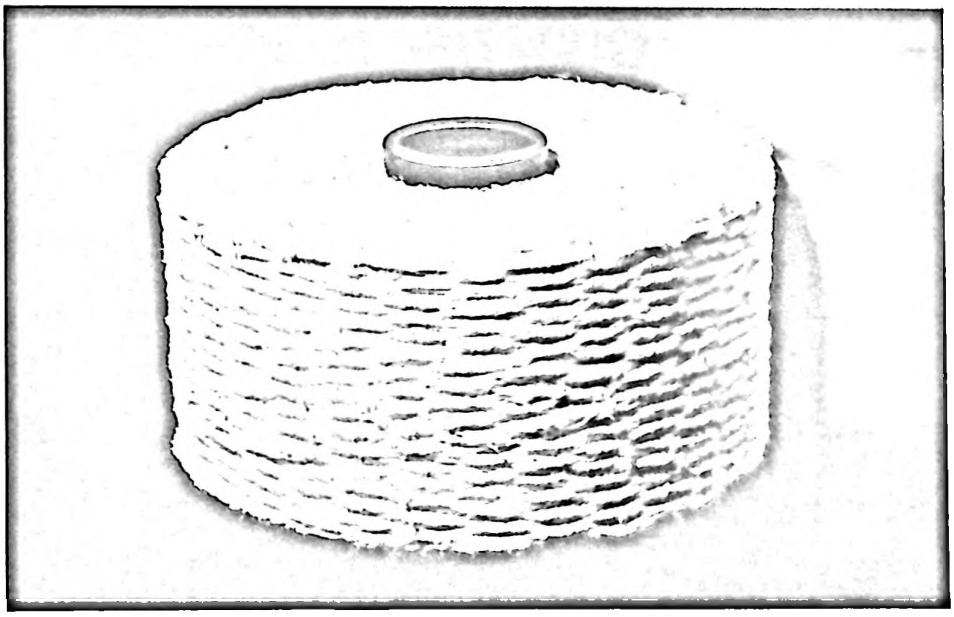
Electrical Insulation Classification: Asbestos roving as made for the electrical industry is furnished in three types, classified on the basis of magnetic rating determinations[5] as follows:

Type 2 (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.

Type 4 (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.

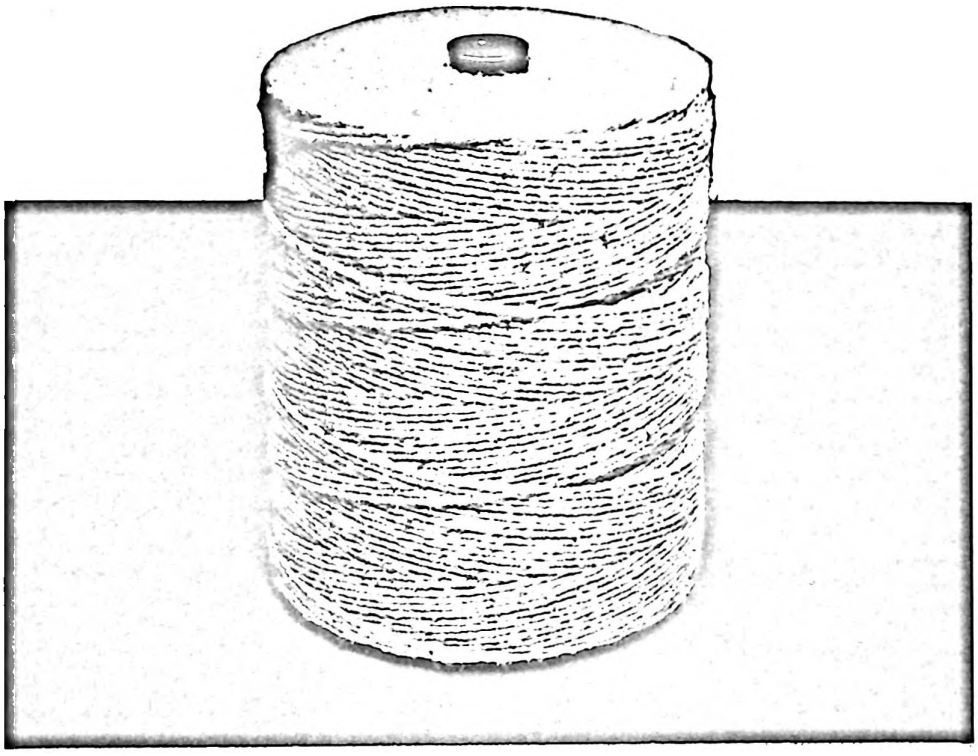
Type 6 (Magnetic Rating 4.00 Maximum) is intended for use where the asbestos is of minor importance as a dielectric, as in the construction of filler or heat and flame resistant walls of electric cables or when used as a lining for control enclosures subject to exposure to electric arcs.

Standard Packages: Asbestos roving is wound on cones and tubes which vary somewhat in size in accordance with customer requirements.



[5]See A.S.T.M. Specification D1118, page 76.

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Asbestos Yarn

MADE from roving which has been mechanically twisted to give it tensile strength, asbestos yarns are the principal components of all asbestos textiles produced by the weaving, braiding and forming processes. As such, they impart to the finished product advantages of thermal stability, electrical insulating value, fire protection, durability and other characteristics of the asbestos fibers from which they are spun.

To meet the many and varied requirements of their intended use, asbestos yarns are produced by the asbestos textile industry in a wide range of constructions. The basic classes are as follows:

Plain (non-metallic) Asbestos Yarn is defined as yarn which consists of (1) asbestos fiber or (2) asbestos and other fibers. The "other fibers," which are usually cotton or other cellulose fibers, are introduced in small percentages during processing either to improve the spinning properties of the asbestos fibers or to meet certain specifications in the end product.

Metallic Asbestos Yarn, also known as wire-inserted yarn, is plain asbestos yarn with an insert of fine wire. The standard insert is one or more strands of .008″ brass wire but for special purposes wire of smaller or larger diam-

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eter may be used and such metals or alloys as copper, zinc, nickel, nichrome, inconel and monel may also be substituted for brass. Metallic asbestos yarns are extensively used in manufacturing asbestos textiles where the end product requires unusually high tensile strength, exceptional resistance to heat or abrasion, or a combination of these properties.

Reinforced Asbestos Yarn is plain asbestos yarn with an insert of yarn made of other fibers, usually cotton and/or one of several synthetic organic fibers. Glass filament may also be used. Reinforced yarns, also referred to as inserted yarns, are particularly adapted to the braiding and weaving processes because of their higher than average tensile strength.

Single and Plied Yarns: The plain, metallic and reinforced asbestos yarns described above are produced as both single and plied yarns, the latter consisting of a number of strands of single yarns twisted together to form a heavier yarn of greater strength. Asbestos yarns are made in a range of cuts[6] (sizes) and in the grades given below. The cut numbers of plain single asbestos yarns with nominal yards per pound and permissible variations are shown in Table 1, A.S.T.M. Specification D 299, reproduced on page 65.

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

Grades: Asbestos yarns are made in all standard A.S.T.M. grades as follows: Commercial, Underwriters', A, AA, AAA and AAAA. (See Table K for percentage of asbestos content in each grade.)

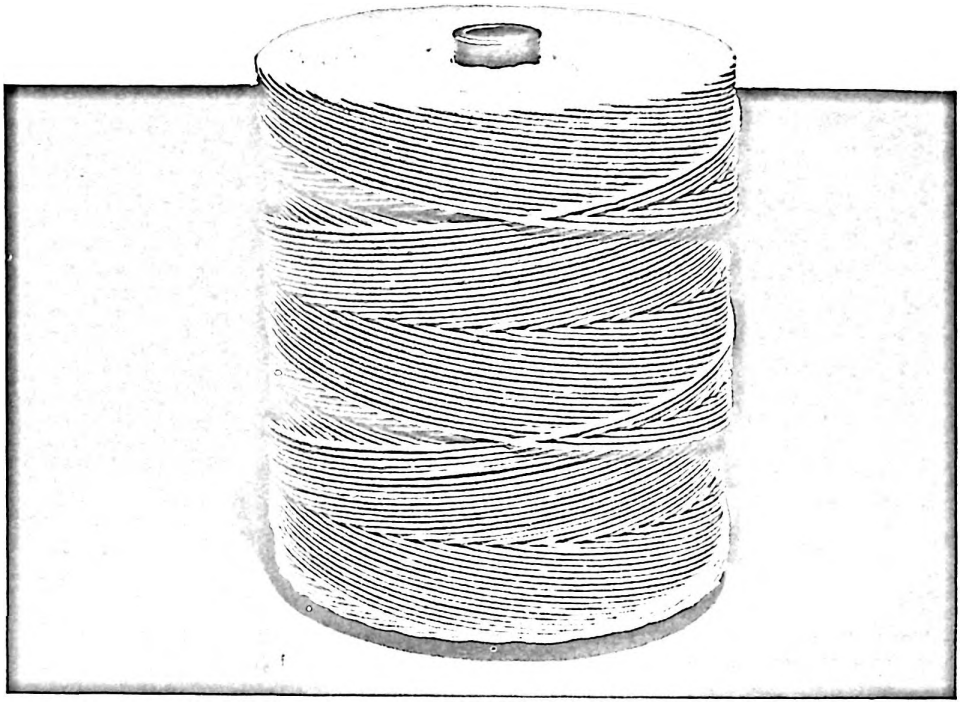
Direction Of Twist: Asbestos yarns are spun with "S" and "Z" twists. (See Glossary for definitions.)

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 metallic. 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. 1022 is a 10-cut, 2-ply metallic yarn containing two wires, and No. 2430 is a 24-cut, 3-ply plain yarn. In a three digit figure, the first digit only indicates the cut. Thus No. 810 is an 8-cut single ply plain yarn.

Standard Packages: Asbestos yarns are wound on paper tubes of various lengths to meet the individual purchaser's requirements.

[6] See Glossary

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Asbestos Cord

TWISTED asbestos cord is made of several strands of asbestos yarn tightly twisted together to form a cord of uniform diameter and high tensile strength. The yarn used may be single or plied,. ferrous or non-ferrous, 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 a yarn 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.

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Grades: Asbestos cord is made in all standard A.S.T.M. grades as follows: Commercial, Underwriters', A, AA, AAA and AAAA. (See Table K for percentage of asbestos content in each grade.)

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

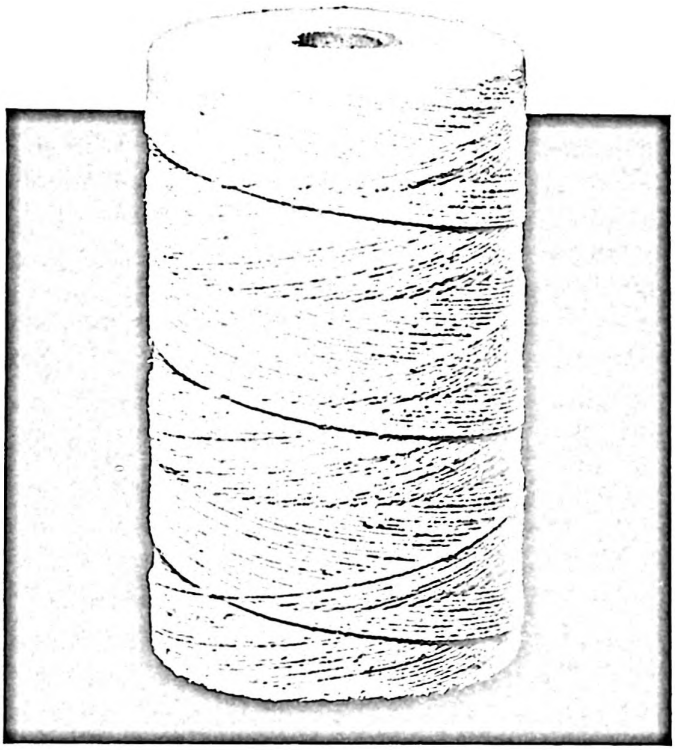
Direction Of Twist: Asbestos cords are plied with "S" and "Z" twists. (See Glossary for definitions.)

Standard Packages: The form of package varies with the practice of the individual textile manufacturer. 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—APPROXIMATE 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
5/16	4.00	25
3/8	5.00	20

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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. For example, one of its well-established uses is for tying incandescent gas mantles on both stationary and portable lighting equipment.

Other 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.

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Asbestos Cloth

Asbestos cloth, woven from asbestos yarns, is produced in many textures, grades, weights and thicknesses to meet the numerous diversified uses of this versatile asbestos textile product. Textures range from open mesh to lightproof and the choice of weaves includes plain, twill and herringbone. Various styles of cloth are also available, including plain (non-metallic), metallic (wire-inserted) and reinforced, as described under "Asbestos Yarn." Representative fabrics are illustrated on the following page.

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

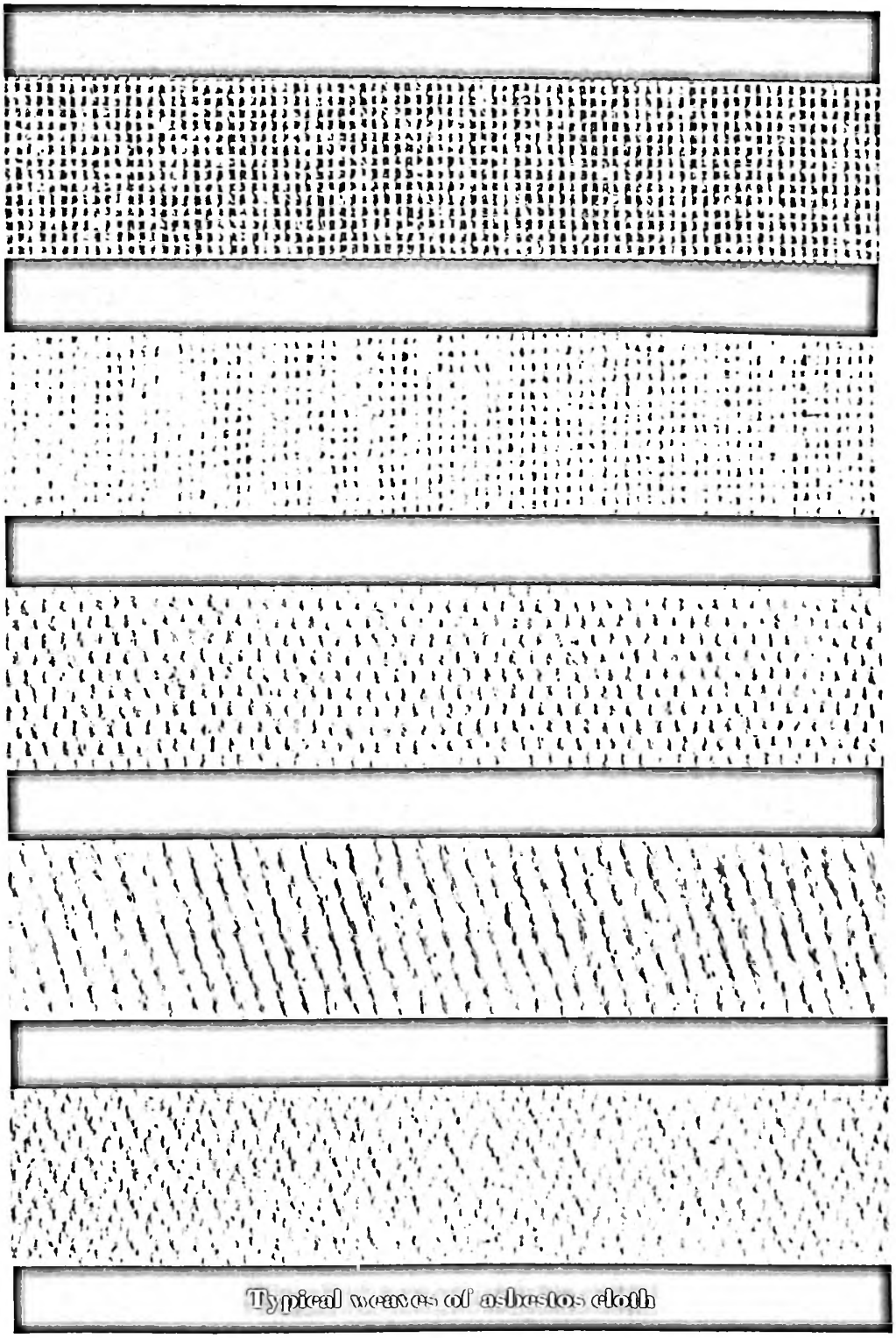
Uses: Because of its inherent incombustibility and thermal stability, asbestos cloth is extensively used wherever these properties are essential in a fabric. Typical examples are the familiar asbestos curtains of theaters and auditoriums, fire-smothering blankets and flameproof draperies, all of which are made of asbestos cloth. The fire-fighting suits worn in the oil fields and the military services as well as the asbestos safety clothing used to protect workers in industrial plants are other familiar applications.

Asbestos cloths are widely used as facings for the traveling conveyor belts servicing ovens, lehrs and dryers, as covers for ironing boards and laundry machine rolls, as industrial furnace hoods, shields for welding booths, and insulation for diesel exhaust pipes.

Many government specifications, particularly those of the United States Navy, require pipe insulation to be protected by an outside jacket of asbestos cloth. All maritime specifications, and many industrial and utility power plants also require asbestos cloth to hold the insulation in place and to serve as a permanent protection and fireproof jacket over pipe and boiler insulation. Underground and overhead piping, both steam and refrigeration, as well as heating and ventilating ducts, are 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 paddle covers, tray linings and lehr curtains in high temperature service. In the field of sound control, specially fabricated asbestos cloths provide acoustical properties which are utilized in reducing undesirable noise levels.

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Typical weaves of asbestos cloth

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Resinated Asbestos Cloth: When asbestos cloth is treated with certain organic resins, the impregnated fabrics exhibit physical properties which uniquely adapt them to the requirements of extreme high temperature service, particularly where high strength-to-weight ratios are important. Such treated fabrics combine excellent ablation and erosion resistant characteristics with low thermal conductivity and high flexural and impact strength. These properties have led to the widespread use of resinated asbestos cloths as thermal insulating materials for vital components of rockets and missiles.

In addition to the organic type resins, ceramic binders are also combined with asbestos cloth to produce materials which not only retain the refractory properties of the ceramic, but also provide high thermal insulating values, light weight and exceptional resistance to physical abuse.

Metallic 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, firewall seals, and as an insulation over high temperature boilers and turbines.

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 unbroken 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.

Grades: Asbestos cloth is made in the complete range of standard A.S.T.M. 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 for percentage of asbestos content in each grade.)

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

Weights: The weight of asbestos cloth varies from a few ounces to several pounds per square yard, depending on weave, grade of yarn used, its

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cut, ply, whether plain, reinforced or metallic and other factors. Tables N and P show the construction of typical asbestos cloths designed for general requirements in weights ranging from one-half to seven pounds per square yard.

Thicknesses: The thickness of single ply cloths ranges 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 A.S.T.M. Specification D 1571.[7]

Standard Packages: Asbestos cloth is supplied in rolls of 50 and 100 linear yards.

TABLE N—CONSTRUCTION OF TYPICAL METALLIC ASBESTOS CLOTHS

Weight Lbs/Sq Yd	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

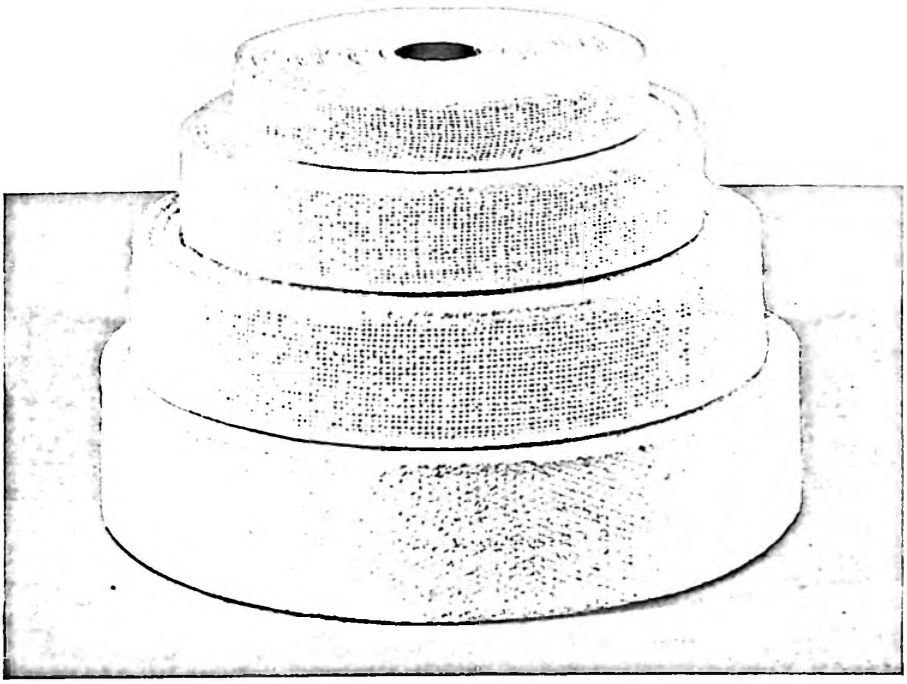
[7] See pages 69 and 70.

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TABLE P—TENSILE STRENGTH AND CONSTRUCTION OF TYPICAL PLAIN ASBESTOS CLOTHS

Weight Lbs/Sq Yd ±7%	ATI Style No.	Construction				Tensile Strength (Grab Method)	
		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	2420	2420	55	50
1.10	18P10G	13	9	1011	1011	90	70
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	1011	1011	125	70
1.40	22P16	19	10	1620	1620	80	40
1.40	22P22	24	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
2.35	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	—	—

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Asbestos Tape

Asbestos tape is a narrow woven fabric with selvage edges. It is made in two classes: plain (non-metallic), and metallic (wire-inserted).

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.

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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 A.S.T.M. grades from Commercial through AAAA. In general, the tapes with higher asbestos content are used where high temperature conditions are encountered. (See Table K 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 ¼". Metallic tapes are woven in thicknesses of 1/16" and heavier. Standard widths of asbestos tape range from ½" to 6". Tolerances conform to A.S.T.M. specifications.[8]

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[9] which serve to identify performance limits.

Type 2 (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.

Type 4 (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

[8] For permissible variations in thickness, width, weight and construction, and other data about asbestos tape not given above, see A.S.T.M. Specification D 315, page 72.
[9] See A.S.T.M. Specification D1118, page 76.

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dielectric strength, as in the construction of heat and flame resistant electrical insulating walls over unit conductors of electric cables.

Type 6 (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 furnished in 36 yard rolls wound on bushings. Industrial tapes of 1/32" and greater thickness are furnished in 100 and 150 foot rolls.

TABLE Q—METALLIC 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	3/16	1	10.0	10.0
	1¼	23.9	4.18		1¼	8.0	12.5
	1½	19.0	5.25		1½	6.5	15.3
	2	15.1	6.62		2	4.8	20.6
	2½	12.1	8.26		2½	3.9	25.2
	3	10.0	9.93		3	3.3	30.3
	3½	8.61	11.61		3½	2.8	35.3
	4	7.55	13.24		4	2.5	40.4
	4½	6.71	14.90		4½	2.2	45.5
	5	6.04	16.55		5	2.0	50.5
	5½	5.49	18.21		5½	1.8	55.5
	6	5.03	19.87		6	1.6	60.6
⅛	¾	16.9	5.9	¼	1	7.1	14.1
	1	12.7	7.9		1¼	5.7	17.6
	1¼	10.9	9.1		1½	4.7	21.2
	1½	9.6	10.4		2	3.5	28.3
	2	6.6	15.2		2½	2.8	35.4
	2½	5.6	17.9		3	2.3	43.6
	3	4.4	22.6		3½	2.0	50.0
	3½	3.8	26.1		4	1.8	56.3
	4	3.4	29.5		4½	1.6	62.6
	4½	3.0	33.0		5	1.4	70.4
	5	2.7	36.4		5½	1.3	77.4
					6	1.1	83.7

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

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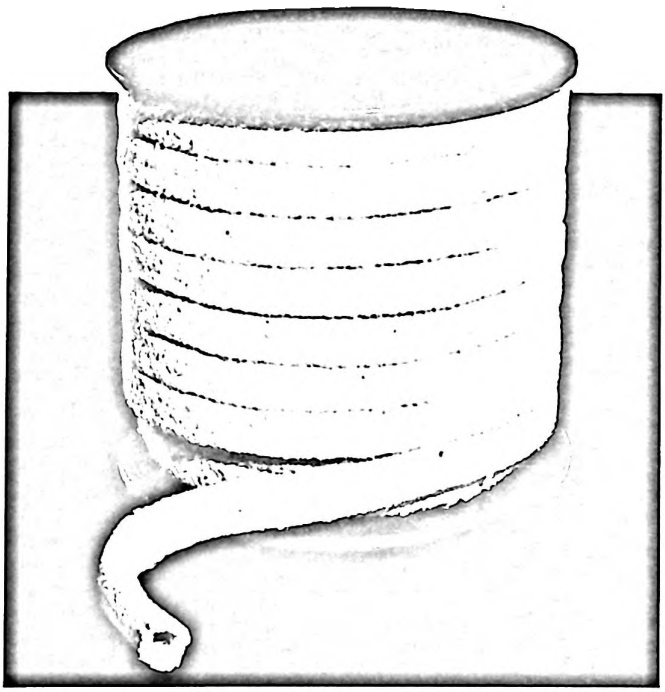
TABLE R—PLAIN WOVEN ASBESTOS TAPE

Asbestos Textile Institute Standards*

Thickness Inches	Width Inches	Approx. Ft. Per Lb.	Approx. Lbs. Per 100 Ft.
0.010	½	340	.29
	¾	248	.40
	1	192	.52
	1¼	153	.66
	1½	130	.77
0.015	½	270	.37
	¾	205	.49
	1	163	.61
	1¼	130	.77
	1½	112	.90
	2	87	1.15
0.020	½	220	.46
	¾	160	.63
	1	125	.80
	1¼	102	1.00
	1½	86	1.16
	2	66	1.52
0.025	½	183	.55
	¾	125	.80
	1	96	1.00
	1¼	78	1.28
	1½	67	1.50
	2	50	2.00
	2½	42	2.40
	3	36	2.80
0.030	¾	93	1.08
	1	70	1.43
	1¼	56	1.80
	1½	47	2.13
	2	35	2.86
	2½	29	3.45
	3	24	4.17
1/32	½	125	.80
	¾	84.7	1.18
	1	60.2	1.66
	1¼	50.0	2.00
	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
	1½	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
3/16	1	12.0	8.3
	1¼	9.7	10.3
	1½	8.0	12.4
	2	6.0	16.6
	2½	4.8	20.8
	3	4.0	25.0
	3½	3.4	29.0
	4	3.0	33.1
	4½	2.7	37.2
	5	2.4	41.4
	5½	2.2	45.5
	6	2.0	49.6
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.

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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.

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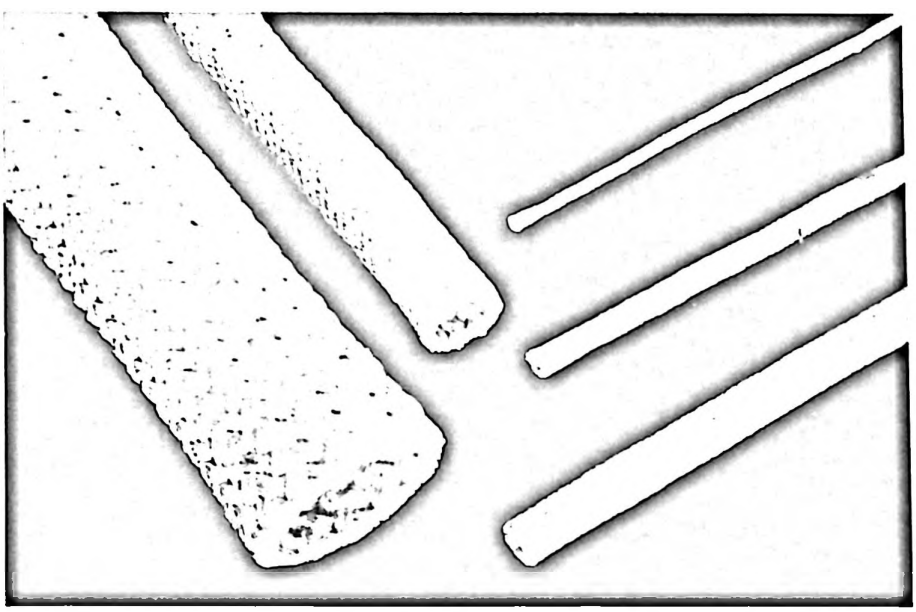
The woven style of asbestos tubing is particularly adapted for the insulation of bus bars. Woven tubing of large diameters is sometimes formed into the dust bags used in pneumatic systems for filtering hot waste gases which constitute a fire and dust hazard.[10]

Grades: Asbestos tubing is made in all standard A.S.T.M. grades—Commercial, Underwriters', A, AA, AAA and AAAA. (See Table K for percentage of asbestos content in each grade.)

Sizes: Braided tubings are produced with inside diameters ranging from 1/64" up to several inches. Wall thicknesses range from less than 1/32" to approximately 1/8".

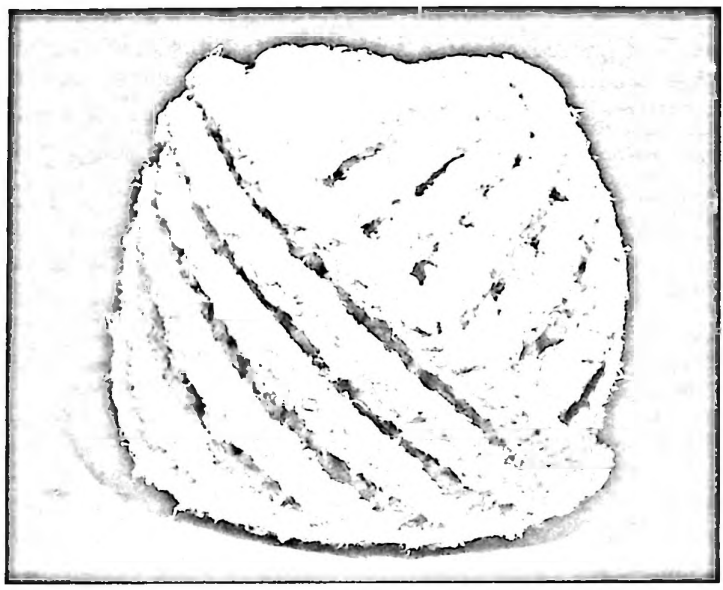
Woven tubings are made in diameters from less than 1" up to 22½".

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



[10] See also "Asbestos Cloth."

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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.

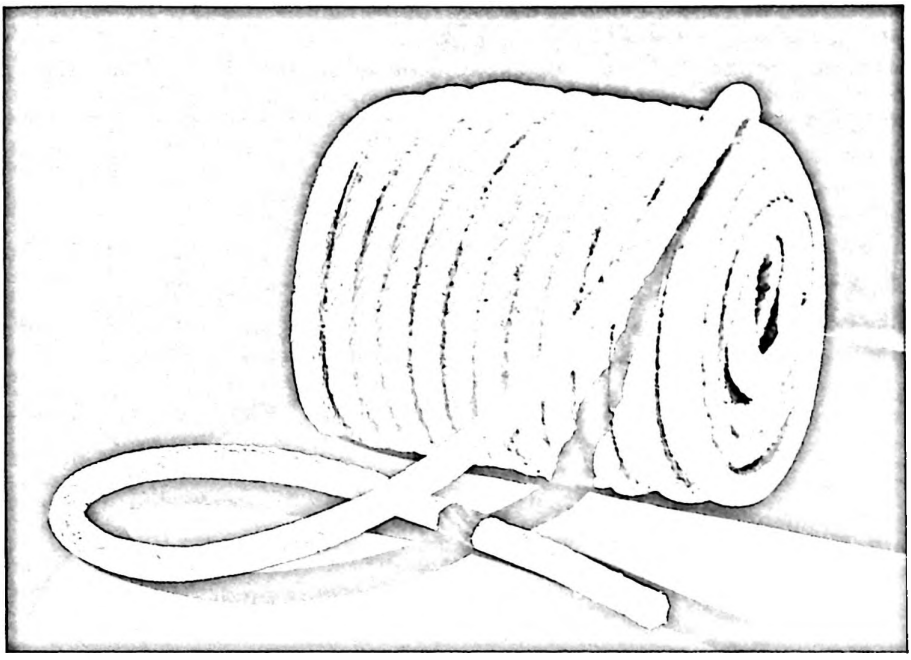
Specially designed asbestos wick is used to wipe excess metal from wire in the process of tinning and galvanizing and as a core for high temperature packings.

Grades: The standard grade of asbestos wick is Commercial but other grades are supplied on order by most manufacturers. (See Table K 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.

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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

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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 for percentage of asbestos content in each grade.)

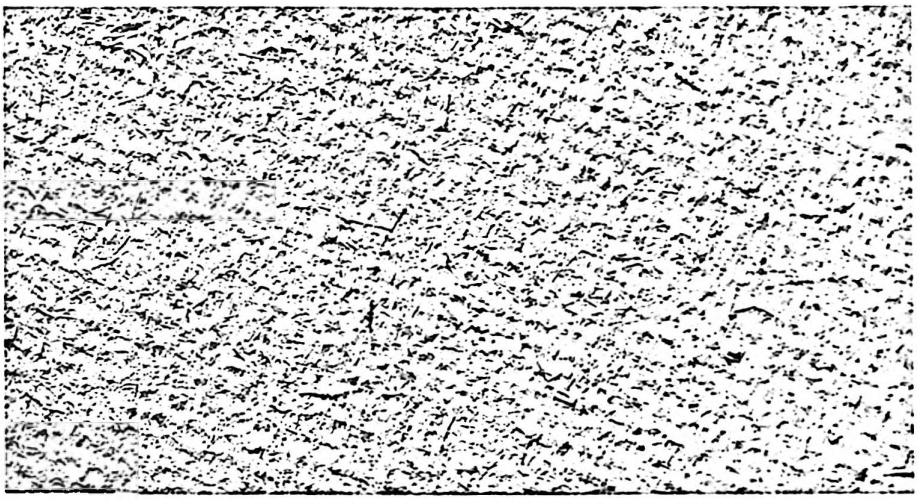
Sizes: Asbestos rope is made in a wide range of diameters, usually from ¼" up to 1½" or 2".

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

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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.

Grades: Non-woven asbestos felts are made in standard A.S.T.M. grades, from Commercial through grade AAAA.

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

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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 the latest information.

Standard Specifications and Methods of Test for

ASBESTOS LAP[1]

ASTM Designation: D 1061 – 58

ADOPTED, 1954; REVISED, 1957, 1958.[2]

This Standard of the American Society for Testing Materials is issued under the fixed designation D 1061; 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 4 and 11 were made in October, 1959.

Scope

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

Definition

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

(*b*) *Asbestos Lap* is supplied in two styles: (*1*) *Style I.*—A ribbon-like formation of felted asbestos fibers. (*2*) *Style II.*—A parallel assemblage of Style I lap.

(*c*) *Asbestos Lap* is supplied in two types: (*1*) ferrous, and (*2*) non-ferrous.

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

Magnetic Rating

4. Asbestos lap shall be made in two varieties, ferrous and non-ferrous, the magnetic rating of which shall conform to the following requirements:

	Magnetic Rating, max
Ferrous lap	3
Non-ferrous lap:	
Underwriters' Grade	0.75
Grade A, AA, and AAA	1

Weight

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

[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the ASTM Committee D-13 on Textile Materials.

[2] Prior to adoption as standard, these specifications were published as tentative from 1949 to 1954, being revised in 1950, 1951, and 1952.

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	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 Paragraphs (*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 1).

NOTE 1.—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. One test specimen weighing not less than 5 g shall be taken from each of the five packages used for determining weight, and dried to constant weight in an oven at 105 to 110 C (220 to 230 F) and the weights of the dried specimens recorded. The specimens shall then be placed in an electric furnace and heated for not less than 1 hr at 800 to 810 C (1470 to 1490 F). After removal from the furnace, they shall be cooled in a desiccator to room temperature, and then weighed. The weight of the residue shall be divided by the factor 0.86 (Note 2) to determine the original weight of the asbestos content. This weight of asbestos content shall be divided by the weight of the dried specimens to obtain the percentage of asbestos. The average of the five determinations shall be the asbestos content of that lot or unit.

NOTE 2.—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.

The presence of carbonates in the asbestos and the amount of carbon dioxide which will be liberated from these carbonates can be determined by the Knorr alkalimeter as described in the Proposed Method of Test for Cotton Content of Asbestos Textile Materials (Referee Method).[3] When carbonates are present, the

[3] See Appendix XI, p. 91.

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asbestos content shall be determined by the combustion-tube method, with corrections for this CO_2 liberated, as described in the Proposed Method.

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.

Magnetic Rating

11. The magnetic rating shall be determined in accordance with the Method of Test for Magnetic Rating of Asbestos Used for Electrical Purposes (ASTM Designation: D 1118).[4]

[4] See p. 76.

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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 the latest information.

Standard Specifications and Methods of Test for

ASBESTOS ROVING FOR ELECTRICAL PURPOSES[1]

ASTM Designation: D 375 – 59

ADOPTED, 1936; REVISED, 1937, 1941, 1942, 1944, 1949, 1952, 1958, 1959.[2]

This Standard of the American Society for Testing 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.

Scope

1. These specifications and methods of test apply to asbestos roving, an asbestos textile product to be used as insulation on heat-resisting fixture wire, flexible cord or heater cord, and similar electrical conductors. 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 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.

[2] Prior to adoption as standard, these specifications were published as tentative from 1933 to 1936, being revised in 1934 and 1936.

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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.

Magnetic Rating

5. Roving shall be made in two varieties, ferrous and non-ferrous, the magnetic ratings of which shall conform to the following requirements:

	Magnetic Rating, max
Ferrous roving	3
Non-ferrous roving:	
Underwriters' grade	0.75
Grade A, AA, and AAA	1

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. Individual test results and the average value of the ten tests shall fall within the respective permissible variations prescribed in the table given in Section 3 (*b*).

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(*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:

$$Y = \frac{7000 \times 20}{W}$$

where:

Y = yards per pound, and
W = weight of 20 yd in grains.

Asbestos Content

9. (*a*) Take two specimens, weighing not less than 5 g each, from each lot or unit sampled and dry to constant weight in an oven at 105 to 110 C (220 to 230 F), and record the weights of the dried specimens. Place the specimens in an electric furnace and heat for not less than 1 hr at 800 to 810 C (1470 to 1490 F). After removal from the furnace cool them in a desiccator to room temperature, and then weigh. Divide the weight of the residue by the factor 0.86[a] to determine the original weight of the asbestos content. Divide this weight of asbestos content by the weight of the dried specimens to obtain the percentage of asbestos. The average of the two determinations made on the specimens from a given lot or unit shall be the asbestos content of that lot or unit.

NOTE 3.—Specimens that are soiled, or have been sized, or otherwise treated shall be prepared for testing by removing hydrocarbon materials with chloroform, and then boiled for 5 min in distilled water. The specimens shall then be tested in accordance with the above procedure.

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

Magnetic Rating

10. Determine the magnetic rating in accordance with the Method of Test for Magnetic Rating of Asbestos Used for Electrical Purposes (ASTM Designation: D 1118).[3]

[a] 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.

The presence of carbonates in the asbestos and the amount of carbon dioxide which will be liberated from these carbonates can be determined by the Knorr alkalimeter as described in the Proposed Method of Test for Cotton Content of Asbestos Textile Materials (Referee Method), see p. 91. When carbonates are present, the asbestos content shall be determined by the combustion-tube method, with corrections for this CO_2 liberated, as described in the Proposed Method.

[3] See p. 76.

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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 the latest information.

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 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.

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 asbestos yarn consists of: (*1*) asbestos fiber, or (*2*) asbestos and other fibers.

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

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

(*e*) *Standard Condition.*—Standard condition of asbestos yarn shall be that reached by the yarn 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 for at least 4 hr, unless otherwise specified, under the above conditions.

(*f*) *Direction of Twist.*—The direction of twist shall be as defined in the Definitions of Terms Relating to Textile

[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the ASTM Committee D-13 on Textile Materials.

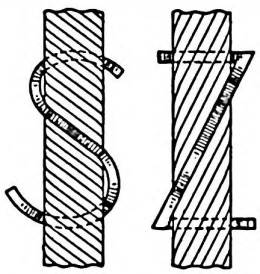
[2] Prior to their present adoption as standard, these specifications were published as tentative from 1928 to 1929. They were adopted in 1929, published as standard from 1929 to 1941, being revised in 1933, 1936, and 1937, but withdrawn and replaced in 1941 by Tentative Specifications D 299 – 40 T which 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.

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Materials (ASTM Designation: D 123),[3] as follows:

Twist, Direction of.—A yarn has S 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 the 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 FOR YARDS PER POUND OF STANDARD SINGLE ASBESTOS YARNS.

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

[3] 1960 Supplement to Book of ASTM Standards, Part 10.

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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 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.

METHODS OF TESTING

Test Conditions

8. 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

9. (*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 10 and 11) 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.

(*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

10. (*a*) *Testing Machine.*—The breaking strength shall be determined on a

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tension testing machine conforming to the Specifications for Textile Testing Machines (ASTM Designation: D 76).[4]

(*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 9. 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)

11. 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

[4] 1958 Book of ASTM Standards, Part 10.

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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

12. (*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 9 (*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

13. (*a*) One test specimen weighing not less than 5 g, shall be taken from each of the tubes used for determining number, dried to constant weight in an oven at 105 to 110 C (220 to 230 F), and the weights of the dried specimens recorded. The specimens shall be placed in an electric oven and heated for not less than 1 hr at 800 to 810 C (1470 to 1490 F). After removal from the oven they shall be cooled in a desiccator to room temperature, and then weighed. The weight of the residue shall be divided by the factor 0.86[a] to determine the original weight of the asbestos content. This weight of asbestos content shall be divided by the weight of the dried specimens to obtain the percentage of asbestos. The average of the five determinations shall be the asbestos content.

NOTE.—Specimens that are soiled, or have been sized or otherwise treated, shall be prepared for testing by removing hydrocarbon materials with chloroform, and then boiled for 5 min in distilled water. The specimens shall then be tested in accordance with the above procedure.

(*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.

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[a] 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.

The presence of carbonates in the asbestos and the amount of carbon dioxide which will be liberated from these carbonates can be determined by the Knorr alkalimeter as described in the Proposed Method of Test for Cotton Content of Asbestos Textile Materials (Referee Method), Appendix XI, see p. 91. When carbonates are present, the asbestos content shall be determined by the combustion-tube method, with corrections for this CO_2 liberated, as described in the Proposed Method.

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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 the latest information.

Tentative Specifications and Methods of Test for

WOVEN ASBESTOS CLOTH[1]

ASTM Designation D 1571 – 58 T

ISSUED, 1958.[2]

These Tentative Specifications have 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. These specifications apply to all single ply asbestos cloths representative styles as listed in Table I.

SPECIFICATIONS

Manufacture

2. Asbestos cloth shall be uniformly and evenly woven from a suitable grade of plain asbestos yarn and shall not contain an undue number of imperfections.

Grade

3. The grade of asbestos cloth shall be determined by the percentage of asbestos by weight, and shall conform to the following requirements:

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

Physical Properties

4. The physical properties and grades of representative cloths shall conform to the requirements prescribed in Table I, subject to the tolerances specified in Sections 5 to 10. Other constructions and grades are available as specified.

TOLERANCES

Width

5. The width of asbestos cloth shall not vary by more than 0.5 in. over or under the specified width.

Thickness

6. The thickness of asbestos cloth shall not vary from that specified by more than the following:

Normal Thickness, in.	Permissible Variations, in.
0.050 and under	±0.005
Over 0.050	±0.010 −0.005

[1] Under the standardization procedure of the Society, these specifications and methods are under the jurisdiction of the ASTM Committee D-13 on Textile Materials.

These Specifications and Methods of Test are in effect a revision and consolidation of the former Methods of Testing Woven Asbestos Cloth (D 577 – 52) and Specifications for Woven Asbestos Cloth (D 677 – 50) which were discontinued in 1958.

[2] Accepted by the Society at the Annual Meeting, June, 1958.

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TABLE I.—PHYSICAL PROPERTIES AND GRADES OF REPRESENTATIVE ASBESTOS CLOTHS.

Style Number	Weight, lb per sq yd	Thickness, in.	Construction		Yarn Number		Grades					
			Warp	Filling	Warp	Filling	Commercial	Underwriters	A	AA	AAA	AAAA
16P18[a]	1.00	0.035	16	13	1820	1810		X				
17P24[a]	1.05	0.035	16	15	2420	2420		X				
20P28[a]	1.25	0.036	27	13	2820	2820		X				
21P14[a]	1.30	0.050	16	10	1420	1210		X				
21P10[a]	1.33	0.055	8	8	1020	1020	X	X				
21P16[a]	1.35	0.045	12	15	1620	1620				X		
22P16[a]	1.40	0.051	19	10	1620	1620		X		X	X	
24P10[a]	1.50	0.055	9	9	1020	1020	X	X				
26P14[a]	1.65	0.053	14	14	1420	1420		X		X		
28P16[a]	1.75	0.063	24	10	1620	1620		X				
29P10[a]	1.80	0.060	16	10	1020	1010		X		X		
29P14[a]	1.80	0.058	20	10	1420	1420		X				
34P10[a]	2.10	0.062	16	9	1020	1020	X	X			X	
36P10[a]	2.25	0.070	18	9	1020	1020	X	X		X	X	
38P12[a]	2.40	0.065	20	12	1220	1220					X	
40P10[a]	2.50	0.075	20	10	1020	1020	X	X		X	X	
40H14[b]	2.50	0.070	27	14	1420	1420	X	X				
48P10[a]	3.00	0.080	18	9	1030	1030	X	X				
48T12[c]	3.00	0.075	30	10	1220	1220					X	
53T12[c]	3.33	0.080	36	12	1220	1220					X	X
59T12[c]	3.70	0.080	40	14	1220	1220					X	X

[a] P = plain weave.
[b] H = herringbone weave.
[c] T = twill weave.

Weight

7. The weight of asbestos cloth shall not vary by more than 7 per cent over or under the specified weight.

Construction

8. The number of warp ends or filling picks per inch of asbestos cloth shall not vary by more than one end or one pick over or under the specified warp or filling counts.

Yarn Number (Cut)

9. The yarn number (cut) of the yarns in asbestos cloth shall conform to the requirements given in Table I of Specifications and Methods of Tests for Asbestos Yarns (ASTM Designation D 299).[3]

Asbestos Content

10. The asbestos content prescribed for the particular grade shall not vary from that specified in Section 3.

[3] See page 65.

METHODS OF TESTING

Sampling

11. (*a*) Each shipment shall be sampled according to the following schedule:

Rolls in Shipment	Rolls Sampled
1 to 2	all
3 to 10	3
11 to 16	4
17 to 25	5
26 to 40	6
41 to 65	7
66 to 79	8
80 or more	10 per cent of shipment

(*b*) A test specimen the full width of the cloth and approximately 1 sq yd in area shall be taken from each sample roll. The prescribed tests shall be made on each sample and the averages from all

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samples shall determine the conformance of the lot to the specification.

Test Conditions

12. 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.

Width

13. The width of the cloth shall be determined in accordance with Section 4 of the General Methods of Testing Woven Fabrics (ASTM Designation: D 39).

Thickness

14. (*a*) The measurement of thickness shall be made with a dead-weight gage in accordance with Section 5 of Methods D 39.

(*b*) Ten thickness measurements shall be made on each test specimen and the average of all measurements shall be reported as the average thickness of the lot. No measurements shall be made within 3 in. of any edge of the specimen and the places of measurement shall be uniformly distributed over the specimen.

Weight

15. (*a*) Each specimen shall be cut the full width of the cloth and have an accurately measured length of not less than ½ yd.

(*b*) The specimen shall be weighed on a calibrated balance to the nearest 0.01 oz and the weight in ounces per square yard calculated.

(*c*) The weight per square yard of the lot of cloth shall be the arithmetic mean of the results.

Construction

16. The average number of warp and filling yarns per inch in any piece shall be determined in accordance with Section 7 of Methods D 39.

Breaking Strength

17. The breaking strength shall be determined by the grab method in accordance with Section 10 of Methods D 39.

Asbestos Content

18. One test specimen weighing not less than 5 g shall be taken from each sample roll and the asbestos content determined in accordance with Section 9 of the Specifications and Methods of Test for Asbestos Content of Asbestos Textile Materials (ASTM Designation: D 375).[4] The average of the determinations shall be the asbestos content of the lot.

[4] See page 63.

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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 the latest information.

Tentative Specifications and Methods of Test for

ASBESTOS TAPE FOR ELECTRICAL PURPOSES[1]

ASTM Designation: D 315 – 58 T

ISSUED, 1958.[2]

These Tentative Specifications have 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. These specifications and methods of test apply to asbestos tape woven from plain asbestos yarn and suitable for electrical purposes.

SPECIFICATIONS

Weave

2. The tape shall be uniformly woven and shall have woven selvage edges.

Workmanship

3. The workmanship shall be first class as shown by even spacing in the weave, freedom from nap and from broken threads, uneven threads, and knots.

Finish

4. The tape shall be calendered.

Sizing

5. No sizing shall be used.

Grade

6. Asbestos tape for electrical purposes shall be Underwriters' grade, having an asbestos content by weight of 80 per cent up to but not including 85 per cent.

Construction and Weight

7. The physical properties of asbestos tapes in widths of ½ to 2 in. and thicknesses of 0.010 to 0.030 in. shall conform to the requirements prescribed in Table I, subject to the tolerances specified in Sections 11 to 14.

Tensile Strength

8. The tensile strength shall be as agreed upon between the manufacturer and the purchaser.

Electrical Properties

9. The number of conducting particles

[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the ASTM Committee D-13 on Textile Materials.

[2] Reverted to tentative and revised by action of the Society, June, 1958.

Prior to their present publication as tentative, these specifications were published as tentative from 1929 to 1933, being revised in 1931. They were adopted in 1933, and published as standard from 1933 to 1958, being revised in 1936, 1937, 1941, 1944, 1949, and 1952.

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in a 10-yd length of tape of 0.015 in. in thickness shall not exceed 100 per in. of width. This requirement applies to 0.015-in. tape only.

Rolls

10. (*a*) The tape shall be wound in rolls on bushings having a length $\frac{1}{16}$ in. shorter than the width of the tape and an inside diameter of $\frac{3}{8}$ or $\frac{1}{2}$ in. as specified by the purchaser. The bushings shall have sufficient strength to resist crushing in packing and shipment.

(*b*) The standard roll shall contain 36 yd of tape, and at least 75 per cent of the rolls in any shipment shall be in continuous lengths. No roll shall consist of more than two pieces. A roll consisting of two pieces shall be properly marked to indicate the location of the break.

(*c*) The outer end of the tape shall be firmly secured. Metallic fasteners are not acceptable.

TOLERANCES

Width

11. The width of the tape shall not vary from that specified by more than the following:

Specified Width	Permissible Variations in Width, in.
1 in. and under	±1/32
Over 1 in.	±1/16

TABLE I.—PHYSICAL PROPERTIES OF ASBESTOS TAPES.

Thickness, in.		Width, in.						
		½	¾	1	1¼	1½	1¾	2
0.010	Total ends	17	24	31	38	44	51	58
	Picks per inch	17	17	17	17	17	17	17
	Pounds per 100 ft, avg	0.27	0.38	0.50	0.62	0.72	0.84	0.96
0.015	Total ends	18	26	33	40	47	55	62
	Picks per inch	15	15	15	15	15	15	15
	Pounds per 100 ft, avg	0.36	0.53	0.68	0.83	0.98	1.15	1.30
0.020	Total ends	16	22	28	34	40	46	52
	Picks per inch	13	13	13	13	13	13	13
	Pounds per 100 ft, avg	0.50	0.70	0.91	1.12	1.32	1.53	1.73
0.025	Total ends	18	25	32	39	46	53	60
	Picks per inch	12	12	12	12	12	12	12
	Pounds per 100 ft, avg	0.59	0.84	1.09	1.34	1.59	1.83	2.08
0.030	Total ends	18	26	33	40	47	55	62
	Picks per inch	11	11	11	11	11	11	11
	Pounds per 100 ft, avg	0.79	1.14	1.47	1.80	2.12	2.48	2.81

Thickness

12. The average thickness of the tape shall not vary from that specified by more than ±0.003 in.

Construction

13. (*a*) The number of picks per inch shall not vary from that specified by more than ±1.

(*b*) The number of ends shall not vary from that specified by more than the following:

Width	Permissible Variations	
1 in. and under	+2	−1
Over 1 in.	+3	−2

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Weight

14. The weight shall not vary from that specified by more than ±10 per cent.

METHODS OF TESTING

Sampling Rolls for Test

15 (*a*) Each shipment of tape shall be sampled as follows:

Number of Rolls in Lot	Number of Sample Rolls
50 and under	3
51 to 100	5
101 to 250	7
251 and over	10

(*b*) The prescribed tests shall be made on each sample roll. Failure of the first samples selected to conform to the requirements of the specifications will necessitate the selection of the same number of rolls for a second test. The averages from all rolls tested shall determine conformance of the lot to the specification.

Test Conditions

16. 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 1.—For the 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.

Width

17. (*a*) The width shall be determined by the use of a standard steel scale so graduated as to obtain the degree of accuracy specified in Section 11. The determination shall be made while the tape lies flat and without tension on a smooth surface.

(*b*) The width shall be taken as the average of five measurements made at least 1 ft apart in any one roll, and the average of the measurements on the sample rolls shall be the width of the lot under test.

Thickness

18. (*a*) The thickness shall be measured in accordance with Section 5 of the General Methods of Testing Woven Fabrics (ASTM Designation: D 39).

(*b*) The thickness shall be taken as the average of ten measurements at ten different places on the sample approximately 12 in. apart, none of which shall be on a selvage edge.

Weight

19. The weight of the tape shall be determined by accurately measuring a sample not less than 1 yd in length and weighing it on a balance sensitive to 0.5 per cent of the weight of the specimen. The length determination shall be made with the material laid flat on a smooth surface and held taut without stretching.

Construction

20. (*a*), *Ends.*—The total number of ends shall be determined regardless of the width of the tape.

(*b*) *Picks.*—The number of picks per inch shall be determined over a length of 3 in.

(*c*) *Number of Tests.*—The number of ends shall be that found by one determination per sample.

The number of picks per inch shall be the average of single determinations at each of five different places on the sample. An accepted thread counting magnifying glass shall be used in making the determinations.

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Tensile Strength

21. (*a*) The tensile strength of the tape shall be determined on a testing machine conforming to the Specifications for Textile Testing Machines (ASTM Designation: D 76).

(*b*) Tests shall be made in the direction of the warp only. Tapes up to and including 1½ in. in width shall be tested in full width. Tapes over 1½ in. in width shall be tested by the grab method in accordance with Section 10 of Methods D 39. The initial length of the test specimens between the clamps shall be 3 in., and the speed of the pulling clamp shall be 12 ± ½ in. per min.

(*c*) *Number of Tests.*—The tensile strength shall be determined on five specimens from each sample roll. The average tensile strength of the five specimens shall be the tensile strength of the roll.

Electrical Properties

22. The test for conducting particles shall be made by passing the tape at a rate of 2 yd per min under a pressure of 7 lb per in. of width at prevailing atmospheric conditions between smooth clean copper rollers, 2 in. in diameter, supported by free-moving bearings. The rollers shall be connected in series with a 110-V, 25-W incandescent lamp, to a 110-V, 60-cycle circuit. The number of flashes or glows of the lamp shall indicate the number of conducting particles. A single test shall be made on a 10-yd length from each of the sample rolls, and the average of the redeterminations shall be considered the number of conducting particles of the lot.

Asbestos Content

23. One test specimen weighing not less than 5 g shall be taken from each sample roll and the asbestos content determined in accordance with Section 9 of the Specifications and Methods of Test for Asbestos Roving for Electrical Purposes (ASTM Designation: D 375).[3] The average of the determinations shall be the asbestos content of the lot.

[3] See page 63.

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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 the latest information.

Standard Method of Test for

MAGNETIC RATING OF ASBESTOS USED FOR ELECTRICAL PURPOSES[1]

ASTM Designation: D 1118 – 57

ADOPTED, 1957.[2]

This Standard of the American Society for Testing Materials is issued under the fixed designation D 1118; the final number indicates the year of original adoption as standard or, in the case of revision, the year of last revision.

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[2a] uniformly distributed over the space occupied by a specimen under test ($\frac{3}{4}$ in. in diameter by $2\frac{7}{8}$ 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 A.S.T.M. Committee D 13 on Textile Materials.

[2] Prior to adoption as standard, this method was published as tentative from 1950 to 1957, being revised in 1957.

First published as information in the special compilation of "ASTM Standards on Textile Materials," October, 1949, p. 492.

[2a] 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 Asbestos Textile Institute, Mr. M. C. Shaw, Philadelphia Textile Institute, Schoolhouse Lane, Philadelphia 44, Pa.—ED.

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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 $4\frac{7}{8}$ 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.

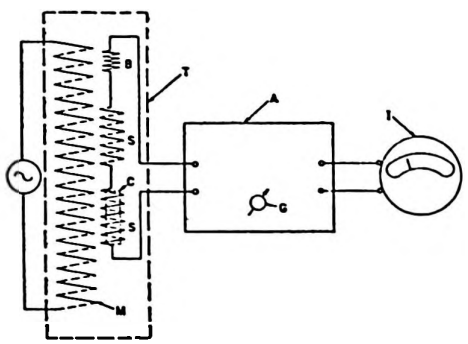
(*b*) Secondary standards for routine measurements can be made using smaller containers, that will fit in the test specimen holder, and having sufficient magnetite to give a deflection equal to the calibrating standard corresponding to the maximum scale value. One secondary standard is necessary for 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 $2\frac{1}{4}$ in. in outside diameter with an inside diameter of 2 in., a length of 18 in., and

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end flanges 5 in. square by 1 in. in thickness. Inside of and concentric with the primary winding is the main secondary winding. This winding shall be in two sections on a compound tube 2 in. in outside diameter with an inside diameter of 1 in. and a length of 18 in. having two winding spaces each 3 in. in length with a diameter of 1½ in. located an equal distance from the ends of the tube and 1⅛ in. apart. Each section shall be wound with one layer of 0.010 in enameled single silk covered copper wire (approximately 220 turns). These coils shall be electrically connected so that their voltages are opposing each other. A small sliding coil, *B*, Fig. 1, shall be connected in series with the secondary winding and is used for fine adjustment of the secondary voltage. This coil shall be made to slide in the end of the secondary winding coil form with provision to lock it in place at any position up to 2 in. inside the form. The winding space for the sliding coil shall be 1 in. in outside diameter with an inside diameter of ⅞ in. and a length of ¼ in. The number of turns on this coil is determined during test as follows:

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 coil at one extreme of its limits of motion 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 2⅞ 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

7. Use the amplifier with the indicating

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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.

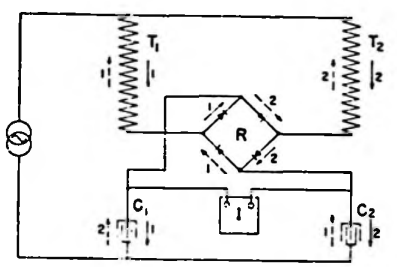


FIG. 2.—Schematic Diagram of Apparatus for Procedure B.

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.

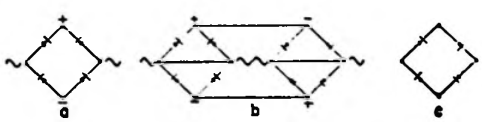


FIG. 3.—Schematic Diagram of Rectifiers and Connections for Procedure B.

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

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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 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 6⅜ in. in length with an inside diameter of 1¾ in. and having end flanges 4 in. in diameter by $\frac{1}{16}$ in. in thickness.

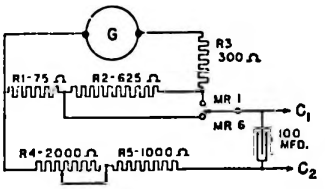


FIG. 4.—Schematic Diagram of Indicating Instrument for Procedure B.

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 ¾ in. and a length of 4⅜ in. and with two wooden stoppers that extend ¾ 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

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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

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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:

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

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

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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 the latest information.

Tentative Specifications and Methods of Test for

INDUSTRIAL ASBESTOS TAPES[1]

ASTM Designation: D 1572 – 58 T

ISSUED, 1958.[2]

These Tentative Specifications have 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. These specifications and methods of test apply to asbestos tape, $\frac{1}{32}$ in. in thickness and over, woven from plain asbestos yarn.

SPECIFICATIONS

Weave

2. The tape shall be uniformly woven and shall have woven selvage edges.

Workmanship

3. The workmanship shall be first class as shown by even spacing in the weave, freedom from nap and from broken threads, uneven threads, and knots.

Grade

4. The grade of the asbestos tape shall be determined by the percentage of asbestos by weight and shall conform to the following requirements:

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

Physical Properties

5. The physical properties of asbestos tapes in thicknesses of $\frac{1}{32}$ to $\frac{1}{4}$ in. shall conform to the requirements given in Table I subject to the tolerances specified in Sections 8 to 12.

Tensile Strength

6. The tensile strength shall be as agreed upon between the manufacturer and the purchaser.

Rolls

7. Standard rolls shall each contain 25 or 100 ft of tape and at least 75 per cent of the rolls in any shipment shall be in continuous lengths. No roll shall consist of more than two pieces. A roll consisting of two pieces shall be properly marked to

[1] Under the standardization procedure of the Society, these specifications and methods are under the jurisdiction of the ASTM Committee D-13 on Textile Materials.

[2] Accepted by the Society at the Annual Meeting, June, 1958.

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indicate the location of the break. The outer end of the tape shall be firmly secured.

TABLE I.—PHYSICAL PROPERTIES OF ASBESTOS TAPES.

	Thickness, in.				
	1/32	1/16	1/8	3/16	1/4
Warp ends per inch (includes binder ends)	28	18	34	33	45
Picks per inch	11	8	12	12	18
Feet per pound of 1-in. tape, avg	60	40	16	12	8

TOLERANCES

Width

8. The width of the tape shall not vary from that specified by more than the following:

Thickness, in.	Specified Width	Permissible Variation, in.
1/32 and 1/16	1 in. and under	±1/32
	over 1 in.	±1/16
1/8, 3/16, and 1/4	all widths	±1/16

Thickness

9. The thickness of the tape shall not vary from that specified by more than the following:

Specified Thickness, in.	Permissible Variation, in.	
1/32	±0.003	...
1/16	±0.005	...
1/8	+0.010	−0.005
3/16	+0.010	−0.005
1/4	+0.010	−0.005

Construction

10. (*a*) The number of picks per inch shall not vary from that specified by more than the following:

Tape	Permissible Variation, plus or minus
1/32 and 1/16 in. in thickness	1
1/8, 3/16, and 1/4 in. in thickness	2

(*b*) The number of warp ends per inch (including binder ends) shall not vary from that specified by more than ±2 for all thicknesses.

Weight

11. The weight shall not vary from that specified by more than plus or minus 10 per cent.

Grade

12. The asbestos content prescribed for the particular grade shall not vary from that specified in Section 4.

METHODS OF TESTING

Sampling Rolls for Test

13. (*a*) Each shipment of tape shall be sampled as follows:

Number of Rolls in Lot	Number of Sample Rolls
50 and under	3
51 to 100	5
101 to 250	7
251 and over	10

(*b*) The prescribed tests shall be made on lengths from each roll. Failure of the first samples selected to conform to the requirements of the specifications will necessitate the selection of the same number of rolls for a second test. The averages from all rolls tested shall determine the conformance of the lot to the specification.

Test Conditions

14. 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

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tolerance of ±2 per cent is permitted in relative humidity and ±2 F (1.1 C) in temperature.

NOTE 1.—For the 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.

Width

15. (*a*) The width shall be determined by the use of a standard steel scale so graduated as to obtain the degree of accuracy specified in Section 8. The determination shall be made while the tape lies flat and without tension on a smooth surface.

(*b*) The width shall be taken as the average of five measurements made at least 1 ft apart in any one roll, and the average of the measurements shall be accepted as the width of the lot under test.

Thickness

16. (*a*) The thickness shall be measured in accordance with Section 5 of the General Methods of Testing Woven Fabrics (ASTM Designation: D 39).

(*b*) The thickness shall be taken as the average of ten measurements at ten different places on the sample approximately 12 in. apart, none of which shall be on a selvage edge.

Weight

17. The weight of the tape shall be determined by accurately measuring a sample not less than 1 yd in length and weighing it on a balance sensitive to 0.5 per cent of the weight of the specimen. The length determination shall be made with the material laid flat on a smooth surface and held taut without stretching.

Construction

18. (*a*) *Ends.*—The total number of ends shall be counted on tapes up to and including 1½ in. in width. The ends over a 1-in. width shall be counted on tapes over 1½ in. in width and shall not include selvage yarns.

(*b*) *Picks.*—The number of picks per inch shall be determined over a length of 3 in.

(*c*) *Number of Tests.*—The number of ends shall be that found by one determination per sample when all warp yarns are counted (1½ in. and under) and three determinations per sample when the warp yarns in a 1-in. width are counted (over 1½ in.).

The number of picks per inch shall be the average of single determinations at each of five different places on the sample. An accepted thread counting magnifying glass shall be used in making the determinations.

Tensile Strength

19. (*a*) The tensile strength of the tape shall be determined on a testing machine conforming to the Specifications for Textile Testing Machines (ASTM Designation: D 76).

(*b*) Tests shall be made in the direction of the warp only. Tapes up to and including 1½ in. in width shall be tested in full width. Tapes over 1½ in. in width shall be tested by the grab method in accordance with Section 10 of General Methods of Testing Woven Fabrics (ASTM Designation: D 39). The initial length of the test specimen between the clamps shall be 3 in., and the speed of the pulling clamp shall be 12 ± ½ in. per min.

(*c*) *Number of Tests.*—The tensile strength shall be determined on five specimens from each sample roll. The average tensile strength of the five specimens shall be the tensile strength of the roll.

Asbestos Content

20. One test specimen weighing not

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less than 5 g shall be taken from each sample roll, and the asbestos content determined in accordance with Section 9 of the Specifications and Methods of Test for Asbestos Roving for Electrical Purposes (ASTM Designation: D 375).[3] The average of the determinations shall be the asbestos content of the lot.

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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 the latest information.

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

Standard Methods of

TESTING ASBESTOS TUBULAR SLEEVING[1]

ASTM Designation: D 628 - 52

ADOPTED, 1944; REVISED, 1952.[2]

This Standard of the American Society for Testing 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.

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 Standard Methods of Testing and Tolerances for Tubular Sleeving and Braids (A.S.T.M. Designation: D 354) of the American Society for Testing Materials.[3]

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 plus or minus 2 per cent is permitted in relative humidity and plus or minus 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. The weight, wall thickness, inside diameter, carriers, ends per bobbin, yarn number, and imperfections shall be determined in accordance with Sections 11 to 17, inclusive, of Standard Methods D 354.

Asbestos Content

5. The asbestos content shall be determined in accordance with Section 9 of the Standard Specifications and Methods of Test for Asbestos Roving for Electrical Purposes (A.S.T.M. Designation: D 375) of the American Society for Testing Materials.[3]

[1] Under the standardization procedure of the Society, these methods are under the jurisdiction of the A.S.T.M. Committee D-13 on Textile Materials.
[2] Prior to adoption as standard, these methods were published as tentative from 1941 to 1944.
[3] 1952 Book of ASTM Standards, Part 7.

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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 the latest information.

Tentative Method of Test for

HEAT AGING OF ASBESTOS TEXTILES[1]

ASTM Designation: D 1573 – 58 T

ISSUED, 1958.[2]

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 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.

[2] Accepted by the Society at the Annual Meeting, June, 1958.

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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, ¾ 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

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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.

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APPENDIX XI

PROPOSED METHOD OF TEST FOR COTTON CONTENT OF ASBESTOS TEXTILE MATERIALS (REFEREE METHOD)[1, 2]

This is a proposed method and is published as information only. Comments are solicited and should be addressed to the American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa.

Scope

1. This method covers a test for the determination of the cotton content of asbestos textile materials as lap, roving, yarn, cloth, etc., which permits the determination of the asbestos content by difference.

NOTE.—The ignition method for determining the asbestos content of asbestos-cotton mixtures as described in the Specifications and Methods of Test for Asbestos Yarns (ASTM Designation: D 299),[3] for Asbestos Tape for Electrical Purposes (ASTM Designation: D 315),[3] for Asbestos Roving for Electrical Purposes (ASTM Designation: D 375),[3] and for Asbestos Lap (ASTM Designation: D 1061)[3] will be in error to the extent that the weight loss of the asbestos differs from the accepted 14 per cent average for crysotile. When the asbestos contains carbonates that 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 frequently results in an erroneous classification of the material to a lower grade.

Outline of Method

2. Cotton, a cellulose of composition $C_6H_{10}O_5$, when heated in the presence of oxygen, decomposes into carbon dioxide and water. The weight of the carbon dioxide generated by this combustion amounts to 1.631 times the weight of the cotton, or the weight of the carbon dioxide times 0.6137 will give the weight of the cotton.

However, carbon dioxide is liberated from the decomposition of carbonates in the asbestos as well as from the combustion of the cotton. The amount of carbon dioxide liberated from the carbonates in the asbestos is determined by the Knorr Alkalimeter. The difference between the carbon dioxide generated in the combustion tube and that liberated by the Knorr Alkalimeter is the carbon dioxide produced by the combustion of the cotton. From this, the cotton content of the asbestos textile is calculated.

Apparatus

3. (*a*) *Combustion Train*, as described in the Supplement and illustrated in Fig. 1.

(*b*) *Knorr Alkalimeter*, as described in the Supplement and illustrated in Fig. 3.

Reagents

4. *Hydrochloric Acid* (*1:1*).—Mix 1 volume of HCl (sp gr 1.19) with 1 volume of water.

Preparation of Sample

5. Take a representative sample ot not less than 10 g, and, if the sample is

[1] This proposed method is under the jurisdiction of the ASTM Committee D-13 on Textile Materials.

[2] Published as information, June, 1955.

[3] Appears in this publication, see Contents in Numeric Sequence of ASTM Designations at front of book.

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cloth, separate it into individual yarns and remove any wire or glass insertions. Cut the yarns into lengths of ¼ in. or less and mix thoroughly. Remove all oil or grease by warming with several portions of chloroform, decanting the supernatant liquid each time, or by extraction in a Soxhlet apparatus. Dry the material to a constant weight at 110 C (230 F) and transfer to a tightly stoppered bottle. Store in a desiccator.

Procedure for Total CO_2 by Combustion Tube

6. (*a*) Check the train to insure freedom from leaks and pass a current of oxygen through the system for 10 min to clean out all residual CO_2. Without stopping the oxygen flow, remove the absorption bulbs. Place within the balance case and allow to stand for several minutes. When ready for weighing, open the stopcock momentarily and close again. Weigh and repeat the above procedure. The second weight of the tubes should agree with the first weight within 0.0005 g. If it does not, repeat this process until the two successive weighings agree. Replace the tared tubes in the train.

(*b*) Transfer between 0.5 and 1.0 g of the prepared sample (Section 5), weighed to the nearest 0.001 g, to the clay combustion boat which shall previously have been heated to 1700 F. Without stopping the oxygen flow, open the combustion tube and introduce the boat into the inlet end of the tube, the furnace of which shall be maintained at a temperature of 1700 to 1750 F. Using a clean copper rod, push the boat into the glowing portion of the tube. It is imperative that no CO_2 be lost when the cotton starts to burn as it is shoved into the heated portion of the combustion tube. The combustion tube must be quickly restoppered, or a better method is to use a seal to prevent the products of combustion from diffusing out of the combustion tube while the boat is being pushed into place in the heated portion of the tube.

(*c*) Adjust the oxygen flow to a rate of approximately 200 ml per min. Continue the combustion for 30 min. Remove the absorption tubes and weigh. The gain in the weights of the bulbs represents the CO_2 produced by the burning of the cotton and the decomposition of carbonates in the sample. Record this gain in weight as G_1. Remove the boat from the combustion tube.

(*d*) *Blank.*—Run a blank determination by placing the boat without sample in the combustion tube and passing oxygen through the train as in a determination. Record the gain in weight as G_b. The train should not be used if the gain from the blank is more than 0.0005 g.

(*e*) Calculate the weight of total CO_2 by combustion from 1 g of the sample as follows:

$$G_2 = \frac{G_1 - G_b}{S}$$

where:

G_2 = grams of total CO_2 by combustion for 1 g of the sample,
G_1 = grams gain in weight of the absorption tube for the sample,
G_b = grams gain in weight of the absorption tube for the blank, and
S = grams of sample used.

(*f*) Repeat the procedure on another 0.5 to 1-g portion of the sample and calculate the average value of G_2. When the system is operating properly so there is no gain in weight from the blank, the weight of the absorption tubes after the first determination may be used as the starting point for the second weight.

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Procedure for CO_2 in Asbestos

7. (*a*) Check the gas flow train to insure 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 tubes within the balance case and allow it to stand for several minutes. When ready for weighing, open the stopcock 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 tubes 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 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 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, warm 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 bulb as before. The gain in weight represents the CO_2 in the sample. Record as C_1.

(*c*) Calculate the weight of CO_2 from the asbestos in 1 g of the sample as follows:

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

where:

C_2 = grams of CO_2 from the asbestos for 1 g of the sample,
C_1 = grams gain in weight of the absorption bulb, 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 bulb after the first determination may be used as the starting point for the second determination without repeating the initial process of obtaining constant weight.

Calculation of Cotton Content

8. Calculate the percentage of cotton in the sample as follows:

$$\text{Cotton, per cent} = (G_2 - C_2) \times 0.6137 \times 100$$

$$\text{Asbestos, per cent} = 100 - \text{percentage of cotton}$$

(See Supplement, p. 94.)

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Test for Cotton Content of Asbestos Textile Materials

SUPPLEMENT

Description of Apparatus

A1. (*a*) *Combustion Train*, consisting of the following parts connected as shown in Fig. 1:

(*1*) *Tank of Compressed Oxygen, A*, equipped with a pressure regulator to control the output pressure and a needle valve to control the rate of flow.

(*2*) *Mercury Pressure Gage, B*, (*Optional*) for indicating the oxygen pressure in the train and for relief of overpressure.

(*3*) *Gas Washing Bottle, C*, containing concentrated H_2SO_4 to dry the gases.

(*4*) *Absorption Tube or Cylinder, D*, filled two-thirds full of soda-asbestos absorbent (Ascarite) and one-third full of a suitable drying agent, as shown in Fig. 2, to remove all CO_2 in the entering oxygen.

(*5*) *High-Temperature Combustion Tube, E*, of dense vitreous refractory composition 30 in. in length by 1½ in. in diameter with one end tapered for rubber tubing connection. A 4-in. roll of copper screening shall be inserted in the tube about 8 in. from the end of the tapered outlet.

(*6*) *Electric Combustion Furnace, F*, with adapter plates to accommodate the 1½ in. combustion tube and with a heating chamber 9 in. in length. The furnace shall be equipped with suitable temperature-controlling and temperature-measuring devices.

(*7*) *Drying Tube, G*, containing a suitable drying agent to collect both the water liberated from the asbestos and that generated by the combustion of the cotton.

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

(*9*) *Absorption Tube, I*, similarly filled with a drying agent and soda-asbestos (Ascarite) but in the reverse direction to prevent any CO_2 from entering the system.

(*b*) *Knorr Alkalimeter*, consisting of the following parts connected as shown in Fig. 3:

(*1*) *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.

(*2*) *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.

(*3*) *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.

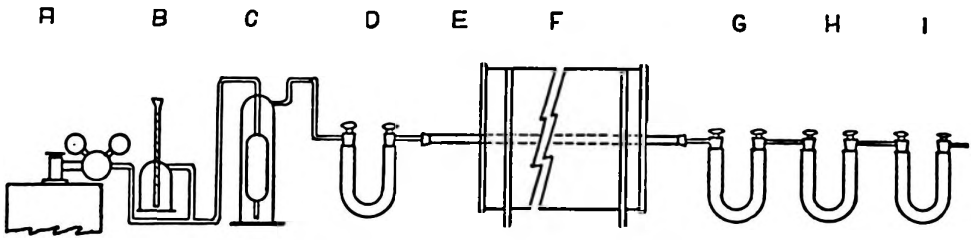


Fig. 1.—Combustion Train for Carbon Dioxide Determinations.

(*4*) *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.

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

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

(*7*) *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.

(*8*) *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.

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

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

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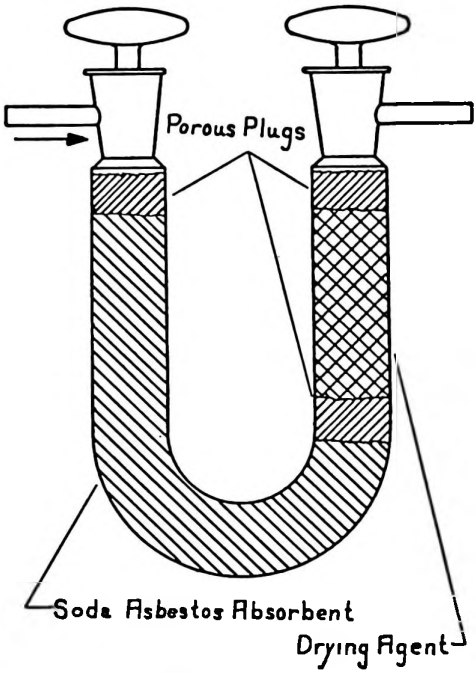


FIG. 2.—Absorption Tube for Carbon Dioxide.

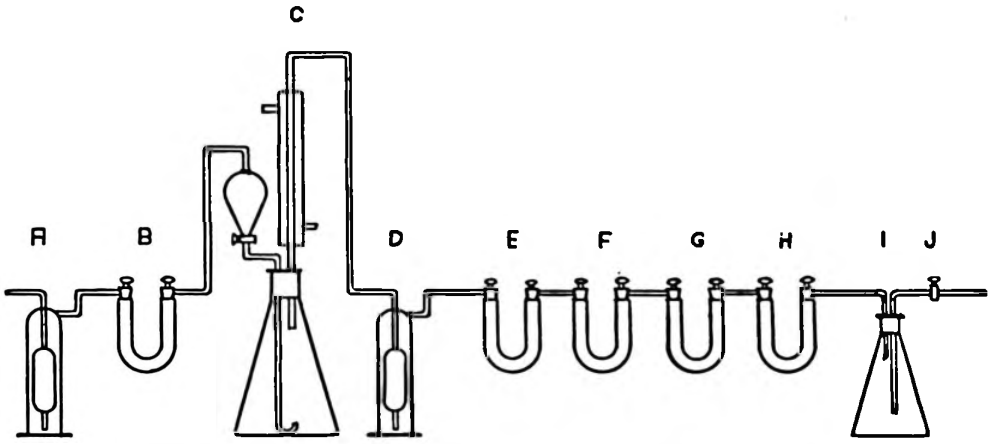


FIG. 3.—Knorr Alkalimeter for Determination of Carbon Dioxide.

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Glossary of Asbestos Textile Terms

Asbestos, Chrysotile—A hydrated silicate of magnesium.

Cloth, Coated—The form of treated cloth where the treating compound is applied to the surface.

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

Cloth, Impregnated—The form of treated cloth in which the interstices are completely filled with the impregnating compound throughout the thickness of the material.

Cloth, Listing—Little used term to designate narrow fabrics or tapes.

Cloth, Metallic—A woven fabric of metallic asbestos yarn.

Cloth, Plain—A woven fabric of plain asbestos yarn.

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.

Cut, Asbestos—Unit of yarn measurement used in the asbestos and glass yarn numbering system. It is the number of 100 yard lengths per pound.

Cones, Paper—A conical shape core for a yarn package.

Ends—An individual warp yarn.

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.

Filling—The yarn, running from selvage to selvage, and interlacing with the warp yarn to form a woven fabric.

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

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GLOSSARY—Cont'd

PICK—One individual filling yarn.

ROPE, BRAIDED—The product formed by braiding one or more jackets over a core of asbestos rope or wick.

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

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

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

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

TAPE, METALLIC—A narrow woven fabric of metallic 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.

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

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

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 portion of the letter "z".



WARP—Yarns running lengthwise in a woven fabric.

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

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 where the reinforcing medium is centered in and covered by the outer material.

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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 at a spinning operation.

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

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

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

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

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

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

YARN, SIZED—Same as Treated Yarn.

YARN, STUFFER—An extra yarn used to give weight or bulk to a multilayer 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 increase strength, lay fibers, impart qualities of the compound, or act as a vehicle for compounds.

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