Handbook of

ASBESTOS TEXTILES



ASBESTOS TEXTILE INSTITUTE

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FOREWORD

THE ASBESTOS TEXTILE INSTITUTE is a non-profit organization of manufacturers of asbestos textile products. 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.

This Handbook contains data which it is hoped will prove helpful to users as well as to students and others who may benefit from knowing more about asbestos textiles and their adaptability to many industrial requirements. The Institute is indebted to its membership for the major portion of the information contained in the following pages and to the American Society for Testing Materials for permission to reproduce the specifications and test methods for asbestos textiles.

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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

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. They insulate toasters, broilers, electric ranges, refrigerators, washing machines and other electrical appliances used in the home, as well as industrial furnaces and ovens, welding machines, motors and transformers and the apparatus and conductors of combat vessels, locomotives and airplanes. They are a basic component of mechanical packings and gaskets. They assure the stamina and heat resistance so essential in automotive and industrial brake linings, clutch facings, gears, bushings, bearings and other vital mechanical parts. They serve such widely diversified uses as safety clothing, fire-smothering blankets, ironing board covers, conveyor belts, insulation for red-hot exhaust pipes, filter cloths and fireproof curtains and draperies. And as reinforcing agents for plastics and other materials they provide physical properties attainable in no other way.

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 since then its development and exploitation have been rapid. Today asbestos is a major component in the manufacture of a wide variety of products, many of which are essential to 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 A and B, pages 9 and 10, provide an interesting comparison of the differences in physical, chemical and mineralogical properties between several varieties of asbestos.

ORIGIN

Although there is no doubt that asbestos is definitely of mineral origin, authorities differ about how it was formed. One widely held theory is that during former geologic periods, when the rock in which asbestos deposits are found was thousands of feet below the earth's surface, it was subjected to the action of hot ground waters containing dissolved salts and carbon dioxide. In the course of time, as the basic composition of the rock was altered, innumerable cracks were opened up. The hot waters entered these



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

cracks and the various mineralizers present acted as solvents, dissolving part of the rock and depositing the closely packed fibers which we know as asbestos. (For a "time-table" of the geologic events leading up to the formation of one type of asbestos—Canadian chrysotile—see page 8.)

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

Chrysotile is a hydrated silicate of magnesium corresponding to the formula $(OH)_6Mg_6Si_4O_{11}.H_2O$.[2] It occurs as veins in the serpentine rock.

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.

Properties: The properties of chrysotile fibers which particularly adapt them to the manufacture of asbestos textiles are length, strength, toughness, flexibilty 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, ranging from 18,000 to 469,000 psi.[3] Rare specimens of chrysotile have been found up to several inches in length. Com-

[1] 1950 Materials Survey, Asbestos, U. S. Department of the Interior, Bureau of Mines, February, 1952.
[2] The chemical formula of chrysotile is also variously expressed as $2SiO_2.3MgO.2H_2O$, $Mg_3Si_2O_5(OH)_4$ and $H_4Mg_3Si_2O_9$.
[3] See Table F, page 12, for a comparison of the tensile strengths of various fibers with chrysotile asbestos.

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mercial fiber, however, 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 also rates high among the asbestos minerals in heat resistance. Thermal analysis investigations conducted in the research laboratory of the Asbestos Textile Institute reveal that at a temperature up to approximately 1490 F, the chrysotile structure is stable; above this temperature it is permanently altered and inverted to another non-fibrous crystalline structure, olivine. However, at 750 F there is a notable deterioration in fiber quality through the permanent depletion of a part of the structural water of crystallization and at 1300 F the structure is nearly completely void of the hydrous elements with attendant further fiber quality deterioration.[4] Table H, page 12, shows the effect of heat on the tensile strength of chrysotile.

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 fibers so fine that they are revealed only by the electron microscope. As shown in Table G, the diameter of individual chrysotile fibers is many times smaller than that of other commercially used fibers.

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 unctious 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 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.

[4] Myril C. Shaw, The Asbestos Content of Asbestos Textiles, New Jersey Ceramic Research Station, Rutgers University, New Brunswick, N. J., March 27, 1950.



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

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

In Canada, Quebec has long been the principal source of chrysotile, although it is now mined in Ontario as well and deposits have recently been found in British Columbia. Canadian output amounted to 876,682 metric tons in 1952,[5] which was approximately two-thirds 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."

Southern Rhodesia ranks second as a supplier of chrysotile fiber with a production of 76,960 metric tons in 1952[5] and is followed by the United States, which produced 46,851 metric tons in the year 1951.[5] (U. S. production was slightly higher in 1952.) The Arizona chrysotile, valued for its low magnetic iron content, is particularly adapted for use as electrical insulation.

In fourth place as a supplier of chrysotile fiber is Swaziland, southern Africa, which produced 31,542 metric tons in 1952.[5] Recently chrysotile has been found in other areas, including Turkey, Venezuela and Colom-

[5] Tonnage figure supplied by Oliver Bowles, U. S. Department of the Interior, Bureau of Mines.

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bia. Large deposits of chrysotile are also located in Russia but no data are available regarding current Russian production.

OTHER TYPES

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 $3Na_2O.6FeO.2Fe_2O_3.16SiO_2.H_2O$.[6] Its composition, like that of chrysotile is found to vary.

Crocidolite is more difficult to process into a spinnable fiber than chrysotile, although some yarns and other textile products are made of this fiber. Its resistance to heat is lower than that of chrysotile but its tensile strength is generally very high, averaging between 100,000 and 300,000 psi. 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 more than 30,000 metric tons in 1951.[7] 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: Amosite is a silicate of iron. Although some doubt has existed that it is a distinct mineral species, recent x-ray and differential thermal analysis by Vermas has established that amosite is a fibrous modification of the monoclinic amphibole grunerite. Its formula is usually expressed as $(Fe.Mg)SiO_3$ or as $(FeO.MgO)SiO_2$.

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. 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 49,000 metric tons were produced there in 1951.[7]

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 is written various ways, sometimes as $(Fe.Mg)_7Si_8O_{22}(OH)_2$, sometimes as $Mg_7(Si_4O_{11})_2(OH)_2$.

[6] The chemical formula of crocidolite is also expressed as $NaFe(SiO_3)_2.FeSiO_3$.

[7] Tonnage figure supplied by Oliver Bowles, U. S. Department of the Interior, Bureau of Mines.

The fibers of anthophyllite are usually brittle and lacking in tensile strength and in the past have not been considered suitable for textiles. Recently, however, specimens of high magnesium anthophyllite have been discovered which are soft and pliable and suitable for textile uses.

Tremolite and Actinolite: These monoclonic 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 $(Ca(Mg.Fe)_3.(SiO_3)_4)$ 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.

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Calendar of Geologic Events Relating to Formation of Canadian Serpentine Deposits*

The asbestos bearing rock of the Canadian serpentine belt is chiefly peridotite, whose main constituent is olivine $(Mg.Fe)SiO_4$.

There were two periods of serpentinization in the Canadian serpentine belt. The first one immediately followed the injection of the ultra-basic rocks and was carried out by hydrothermal solutions genetically related to the ultra-basic magma. The second serpentinization period is much younger and closely followed the Acadian uplift. Asbestos veins were formed only during or immediately after the second serpentinization period.

The following table presents the chronological order of the events in the serpentine belt.

Order	Geological Event	Temp. C	Geological Age
0	Taconic uplift		Post-Ordovician and pre-Devonian
1	Injection and consolidation of ultrabasic rocks and of disseminated chromite	1200 to 900	At end of or immediately after the Taconic uplift
2	First serpentinization of the ultrabasic rocks		
3	Acadian uplift		Post-lower Devonian
4	Injection of massive chromite	500	
5	Injection of aplite and granite		Middle (?) Devonian
6	Second serpentinization; alteration of aplite dikes	500	
7	Formation of asbestos veins followed by talcification	350 or higher	Middle or upper (?) Devonian
8	Injection of magnetite	300 or higher	
9	Precipitation of lime-magnesia silicates	250	
10	Precipitation of zeolites, carbonates and similar minerals	200 or lower	Upper Devonian

* Canadian Mining Journal, Vol. 68, No. 3, 1947, pp. 157-167

TABLE A—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%
Theoretical Formula...	$3MgO.2SiO_2.2H_2O$	$NaFe(SiO_3)_2.FeSiO_3 \times H_2O$	$(Fe.Mg.)SiO_3$ 1-5% H_2O	$(Mg.Fe)_7Si_8O_{22}(OH)_2$	$Ca_2Mg_5Si_8O_{22}(OH)_2$	$Ca(Mg.Fe)_3(SiO_3)_4 \times H_2O$
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 (pseudo-orthorhombic ?)	Monoclinic	Orthorhombic†	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
Origin.....	Alteration and metamorphism of basic igneous rocks rich in magnesian silicates	Regional metamorphism	Metamorphic	Metamorphic, usually from olivine	Metamorphic	Results of contact metamorphism
Veining.....	Cross and slip fibers	Cross fiber	Cross fiber	Slip, mass fiber unoriented and interlaring	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±
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

†Recent studies have established that amosite is monoclinic—see page 6

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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 Heat	Good. Brittle at high temp.	Poor, fuses	Good. Brittle at high temp.	Very good	Fair to good	———
Tensile Strength, psi	18,000 to 469,000†	100,000 to 300,000	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 †Harris Research Laboratories, Washington, D. C.

TABLE C—CHEMICAL COMPOSITION OF VARIOUS TYPES OF ASBESTOS*

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

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

TABLE 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

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TABLE F—COMPARISON OF TENSILE STRENGTHS OF VARIOUS FIBERS WITH ASBESTOS*

Type of Fiber	Tensile Strength (psi)
Acetate Rayon	18,000 to 23,000; 22,000 to 30,000†
Nylon	65,000 to 80,000; 88,000 to 117,000†
Glass	250,000 to 315,000
Orlon	60,000 to 80,000
Cotton	42,000 to 125,000
Silk	45,000 to 83,000
Wool	17,000 to 28,000
Asbestos (Chrysotile)	18,000 to 469,000‡

*Tests conducted by Harris Research Laboratories, Washington, D. C.
†Depending on type
‡The average tensile strength of 56 asbestos fibers tested was 72,000 psi

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

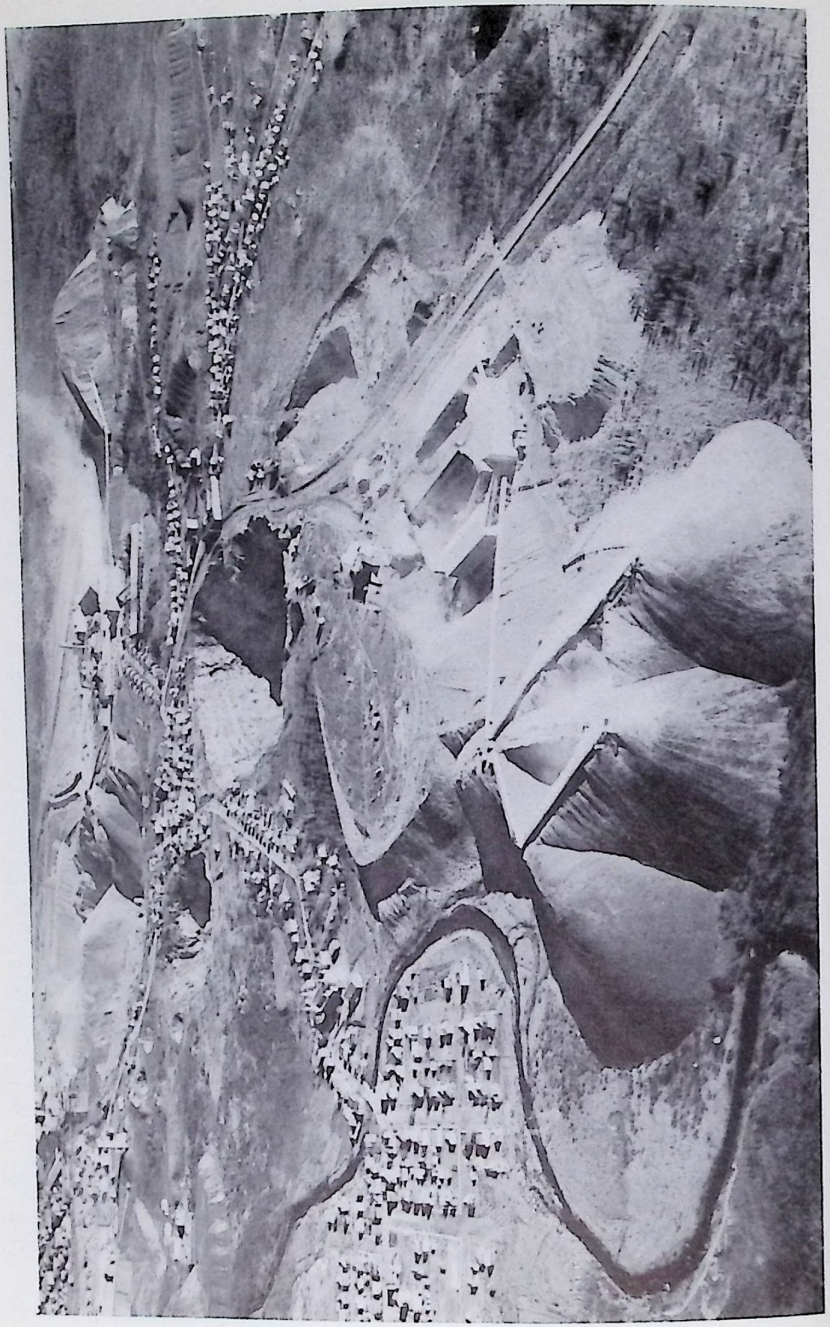
*Canadian Mining and Metallurgical Bulletin, April, 1951

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

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, either by means of a cableway system or by cars or trucks into which it is loaded, usually by cranes or 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



An open pit asbestos mine

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Hand cobbing crude asbestos

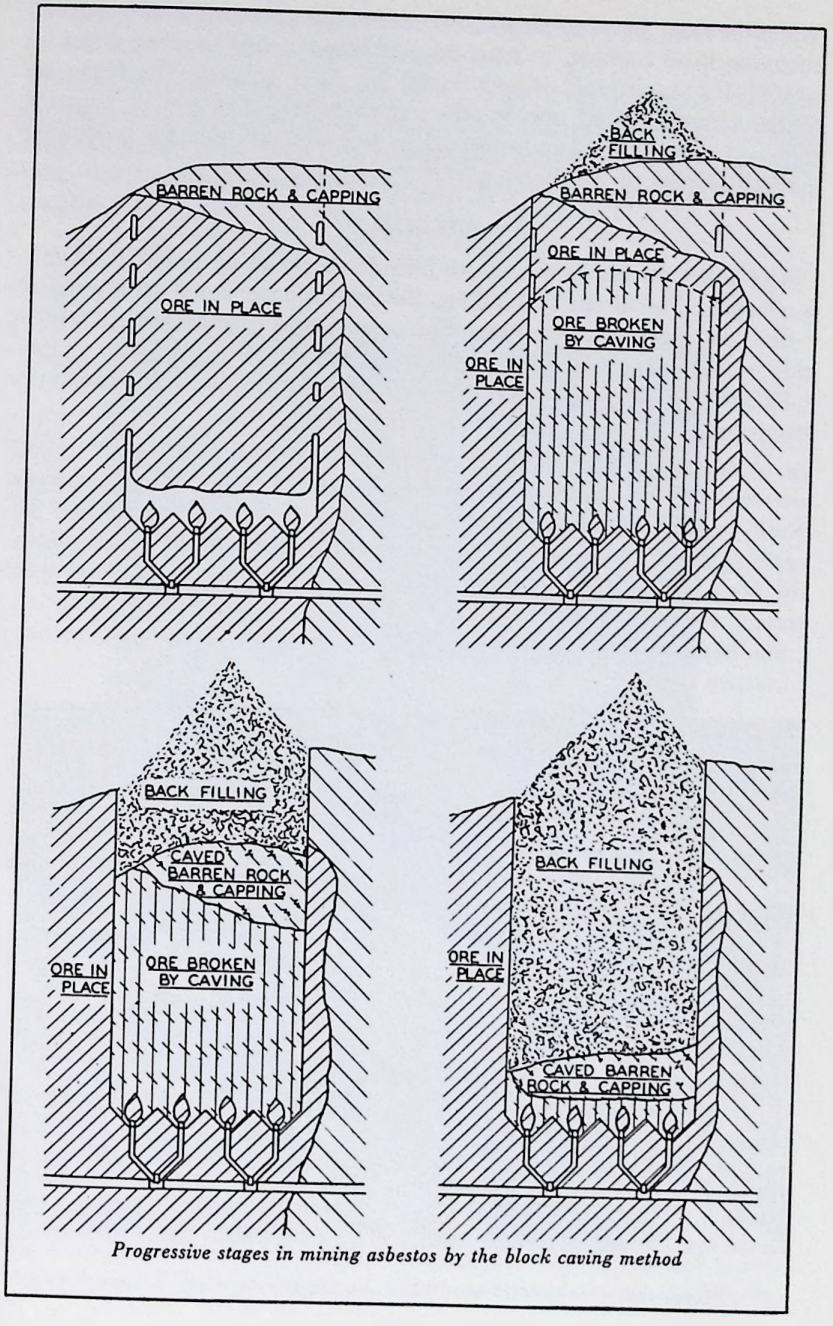
minerals, has been introduced. In one method, known as block caving, large blocks of ore are extracted with a minimum of drilling and blasting by undercutting the ore body, then blasting out the supporting columns and allowing the ore to break down from its own weight. See diagram, page 17.

Whatever the mining methods employed, the percentage of fiber recovered from the ore is small, the average yield from Canadian mines being less than five per cent.[1] This means that approximately twenty tons of asbestos-bearing rock must be mined in order to produce a single ton of usable fiber. Of the total tonnage of asbestos fiber extracted from the mines of the world in recent years, only about four per cent consists of grades that are suitable for processing into textiles.[2]

COBBING

From a production standpoint, Canadian asbestos fibers may be divided into two main groups: crude and milled. Crude fibers—those grades measuring from ⅜″ to ¾″ and longer—are recovered in a different manner than the milled fibers of shorter length. The ore containing veins of these longer fibers is segregated when it is broken in mining or subsequently hand picked from conveyor belts. It is first dried and screened, then each piece that has any adhering rock or other impurities is pounded

[1] C. V. Smith "Asbestos Mining Methods," Asbestos, Philadelphia, Pa.
[2] 1950 Materials Survey, Asbestos, U. S. Department of the Interior, Bureau of Mines, February, 1952.



Progressive stages in mining asbestos by the block caving method

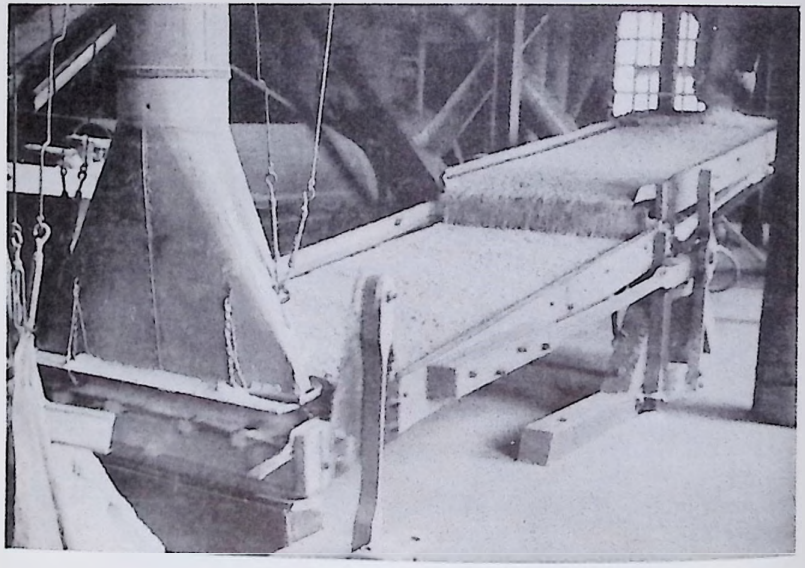
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with a cobbing hammer to free the undesirable portion. The operation, known as hand cobbing, is better adapted to preserving the long fibers intact than a mechanical process would be. After cobbing, the fibers are further cleaned, sorted into lengths and then bagged in 100 lb. bags for shipment. The long fibers recovered in this way are used for processing asbestos textiles of the finest quality.

MILLING

Milled fibers for textile use, which include all grades up to 3/8" in length, are recovered by mechanical milling, the process being based upon physical differences between the asbestos fibers and the serpentine rock in which they occur. The flexible fibers, when subjected to crushing pressure, simply split into smaller groups, while the rock, which is brittle, is shattered into fragments.

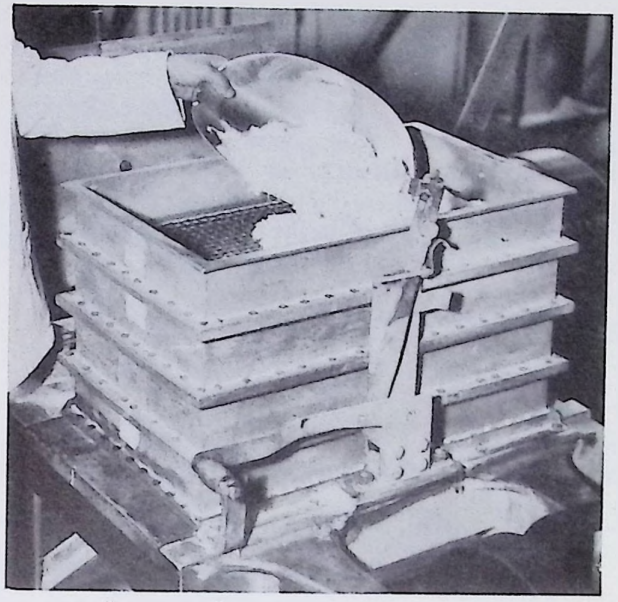
In consequence, the milling process consists essentially of several successive stages of crushing to open up the fibers and free them from the rock. Each step is followed by screening to remove the fines produced by crushing and by air separation to remove the semi-opened fibers. Although the fibers are tough and strong, specially designed crushing machines and techniques are used to minimize fiber damage. Separation is usually accomplished by large suction hoods that operate on the vacuum cleaner principle.



Shaker screen with suction hood which lifts the asbestos fibers after crushing

Following separation, the milled fibers are further opened, cleaned, graded according to length and bagged for shipment.

The crude grades when shipped are in lump form and must therefore be fiberized at the textile plant. Milled fibers that are to be used for spinning, although opened up to a considerable extent by the milling operation, also require additional processing before they are suitable for use in textiles.



The "shaker box" test — standard method for grading Canadian asbestos fibers

GRADING

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. A standard method of grading Canadian chrysotile fibers according to their length has been adopted and generally accepted by the American asbestos industry. It is the Quebec Asbestos Producers' Association Screen Test, commonly known as the "shaker box" test.

The machine used consists of three rectangular screens held in frames measuring 24½" by 14¾" by 3½" deep, one above the other. The top

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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 328 rpm for two minutes by means of a standard mechanical device which is driven by an eccentric with 25/32" throw and 1 9/16" travel. 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 3R fiber.

Other methods of grading are in use in other countries.

TEXTILE GRADES

Canadian Chrysotile: Only the longest, costliest grades of Canadian chrysotile fibers are used in the processing of asbestos textiles. The standard 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
	3F	7-7-1½-½[3]
	3K	4-7-4-1[3]
	3R	2-8-4-2[3]
	3T	1-9-4-2[3]
	3Z	0-8-6-2[3]

Note. Canadian chrysotile is also produced as shorter milled fibers, designated as Groups 4 to 9, inclusive. These fibers are adapted to numerous commercial uses but are not of sufficient length for processing into textiles.

[3] See "Grading"

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

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

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

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

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

Grade	Length of 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.[4]

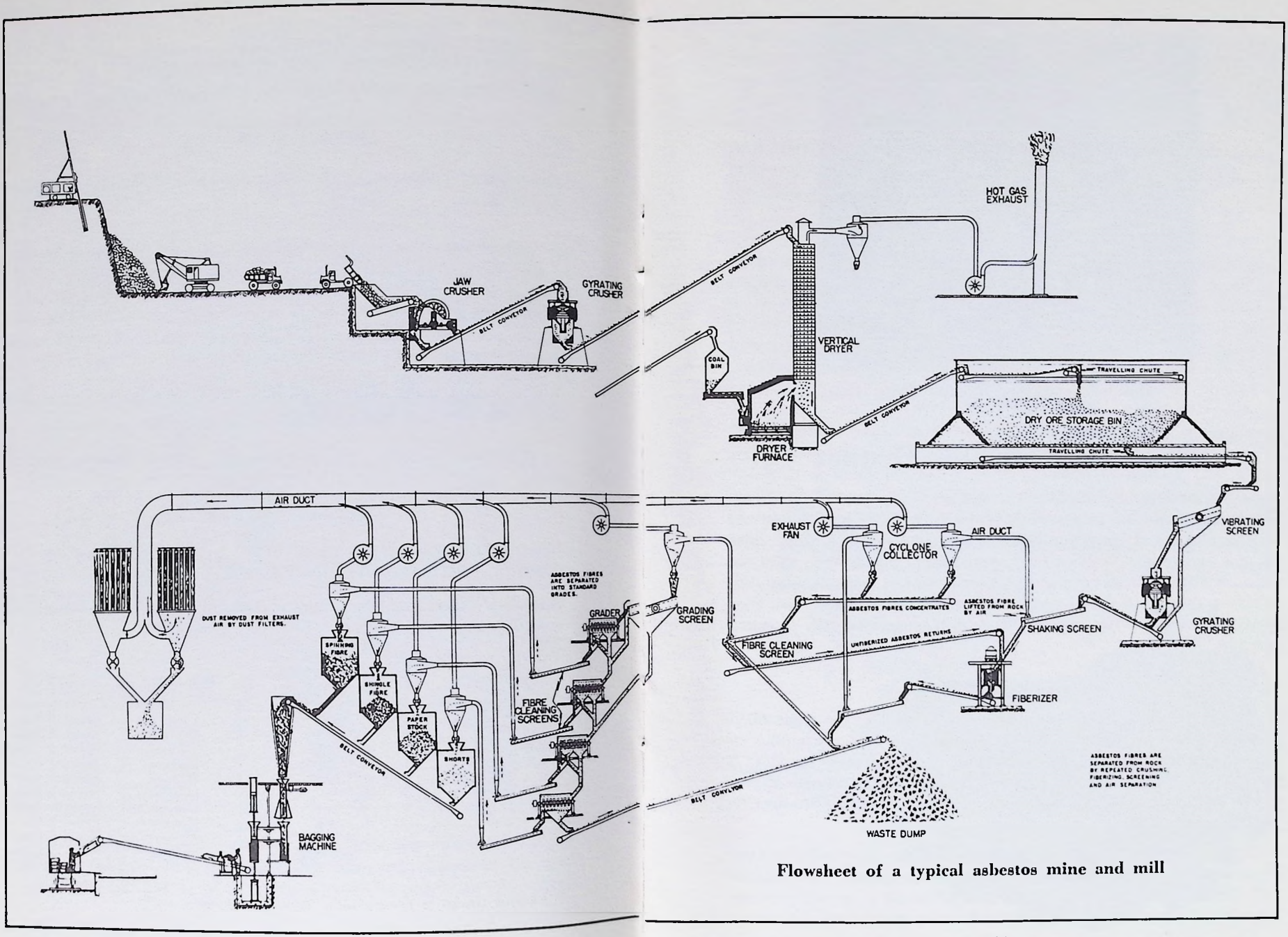
Crude	Fiberized	Length of Fiber
TX	TDX	Plus 1½"
T1	TD1	⅞" to 1½"
T2	TD2	½" to ⅞"
T3	TD3	¼" to ½"
T4	TD4	Minus ¼"

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

Symbol	Range of Average Fiber Lengths	Designation	Color
D-3	2" to 6"	Long	Brown & Gray
D-11	½" to 2"	Medium	Brown & Gray
M-D	½" to 2"	Medium	Brown & Gray
D-X	½" to 2"	Medium	Brown & Gray
M	½" to 2"	Medium	Brown & Gray
S-2	3/16" to 2"	Medium	Brown & Gray
K-3	½" to 2"	Medium	Brown & Gray
W-3	½" to 2"	Medium	Brown & Gray
S-K	3/16" to 1"	Shorts	Brown & Gray
S-W	3/16" to 1"	Shorts	Brown & Gray

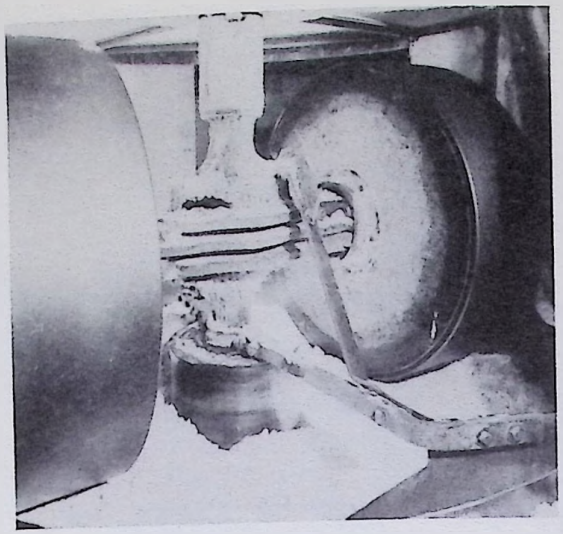
[4] "Asbestos Grades in South Africa," Asbestos, December, 1948

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Flowsheet of a typical asbestos mine and mill

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

Processing Asbestos Textiles

The asbestos fibers as received at the textile plant may be of two types: (a) crude or unmilled fibers, which are in the form of small lumps and must be fiberized or opened up before using, and (b) milled fibers, which are in a semi-opened condition but require further treatment to effect the degree of fiberization so essential to the production of quality textiles. The processing consists of several operations, each of which brings about additional subdivisions of the fiber bundles until they are eventually separated into soft, silky fibers.

FIBERIZATION

After each bag of fiber has 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. These run in a circle upon a bed where the asbestos is constantly deflected back under the wheels. Separated impurities are then removed by screening.

Milled fibers may or may not require this preliminary chaser mill treatment depending on the extent to which they have been opened at the asbestos mill. Those that do not require it are passed through a vertical opener or a rotating toothed cylinder known as a willow that effects finer fiberization.

The fibers next go to a grader which consists of an enclosed shaft revolving horizontally and furnished with steel paddles which literally beat the fibers, removing magnetic iron particles as well as traces of serpentine and other extraneous non-fibrous impurities. Unopened fibers are also separated here and returned to the openers for further processing.

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.

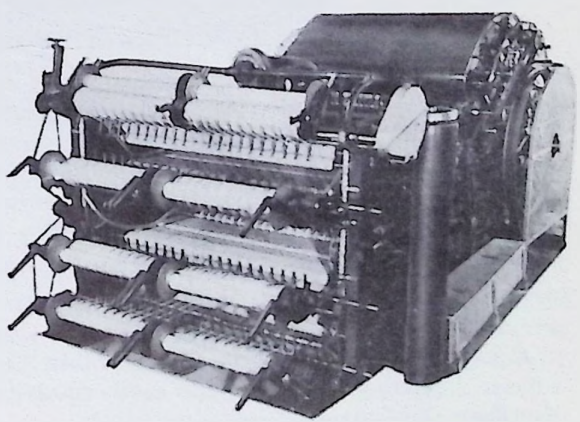
BLENDING AND MIXING

To obtain desired characteristics in the finished product, different types or grades of asbestos fibers are generally blended at this point. Small percentages of organic fibers such as cotton or rayon may then be added as carriers or supporting agents to improve spinning properties or to meet certain requirements in the specific end product. The latter operation is known as mixing.

CARDING

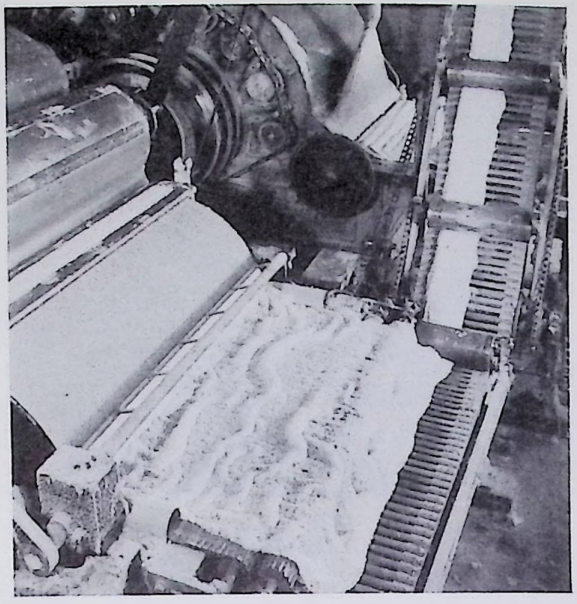
This operation, similar to that employed in the processing of wool, completes the opening and cleaning of the fibers. Under the teasing action of thousands of needle-pointed wires which form the working face of the "clothing" that covers the cylinders of the carding machine, the fibers are combed into a relatively parallel arrangement, forming a tenuous web.

When it is separated into ribbons, rubbed mechanically and condensed into untwisted strands, this web becomes roving, the asbestos textile product from which yarns are produced.



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

LAPPING

The fibrous web as it comes from the carding machines is in a felted ribbon-like form known as a sliver. In the lapping operation, a number of slivers are wound parallel into roll form. These laps, as they are called, are supplied to fabricators who re-card them for insulating electrical wires and cables.

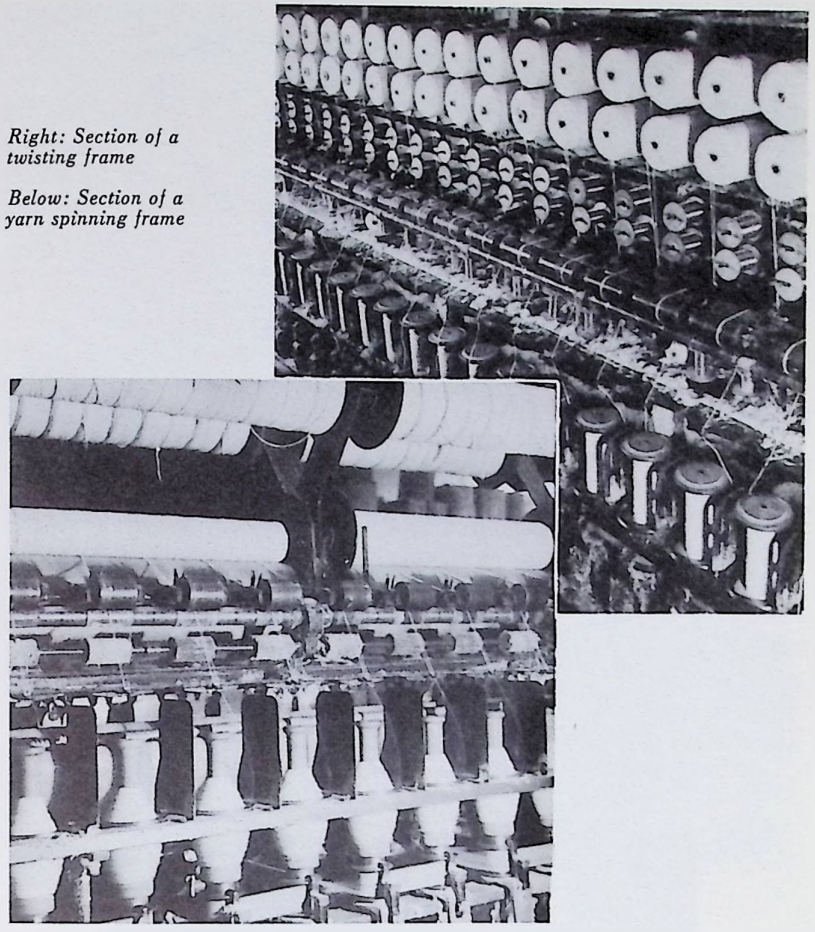
SPINNING, TWISTING AND FORMING

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 facilitate further processing and provide tensile strength. 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. The latter is achieved by having the single yarns under equal stress so that they each contribute their maximum individual tensile to the strength of the cord.

Right: Section of a twisting frame

Below: Section of a yarn spinning frame



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

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

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edges of the fabric, while the filler yarns (picks) interweave these together transversely. The construction of the cloth is controlled by regulating the number of ends and picks per inch.

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

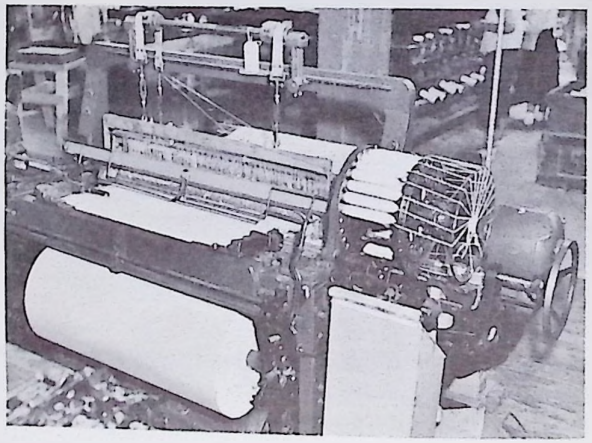
BRAIDING

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.

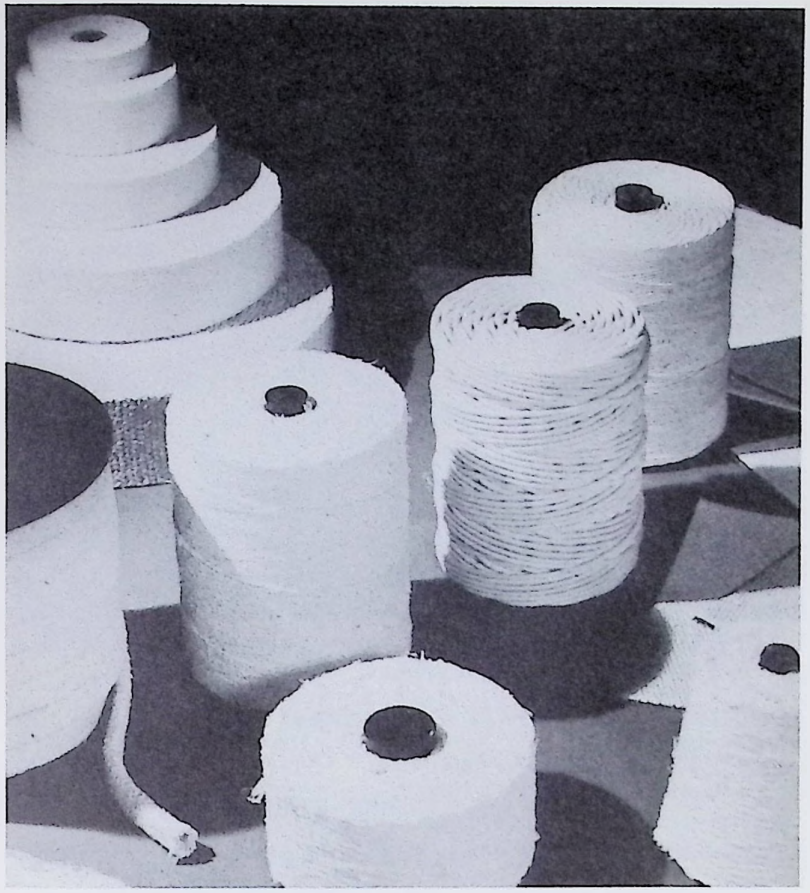
Many kinds of braids, both round and square, may be produced by varying the number of ends of yarn wound parallel on the braider tube, by changing the tension applied and by adding mechanical attachments to the braider.

INSPECTION AND QUALITY CONTROL

During their manufacture, asbestos textiles are inspected, weighed and tested for strength, heat resistance 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 for possible flaws and to insure that the quality standards established by the manufacturer have been met.



An automatic loom of the type used for weaving asbestos cloth



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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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 established by the American Society for Testing Materials with the percentage of asbestos content for each grade.[1] This method of grading applies to all products

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%

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.

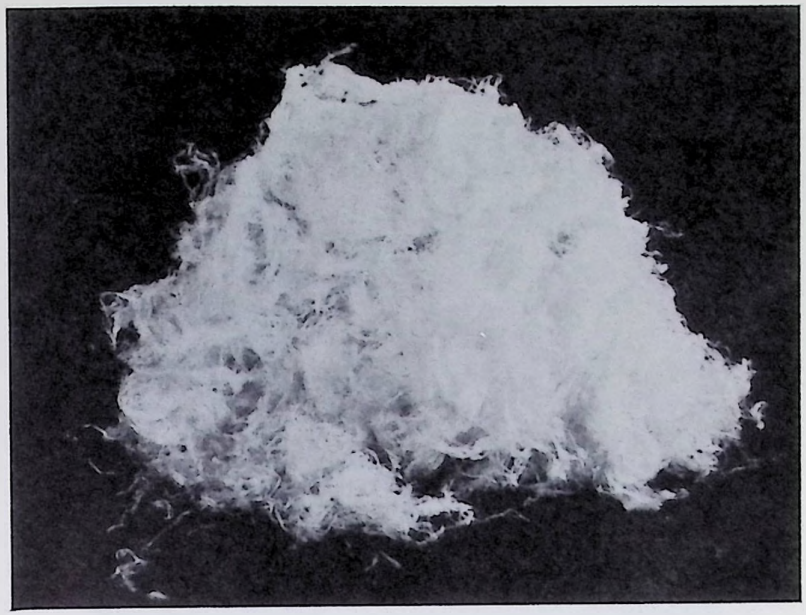
SERVICE TEMPERATURES

In general, the approximate service temperatures for each grade are as follows:

Commercial Grade	up to 400 F
Underwriters' Grade	up to 450 F
Grade A	up to 550 F
Grade AA	up to 600 F
Grade AAA	up to 750 F
Grade AAAA	up to 900 F

For higher temperatures than those shown above, a textile made with metallic (wire-inserted) asbestos yarn is sometimes employed.

[1] See A.S.T.M. Specification D 299, reproduced on pages 62 to 66, for the test methods used to determine grades.



Carded Asbestos Fiber

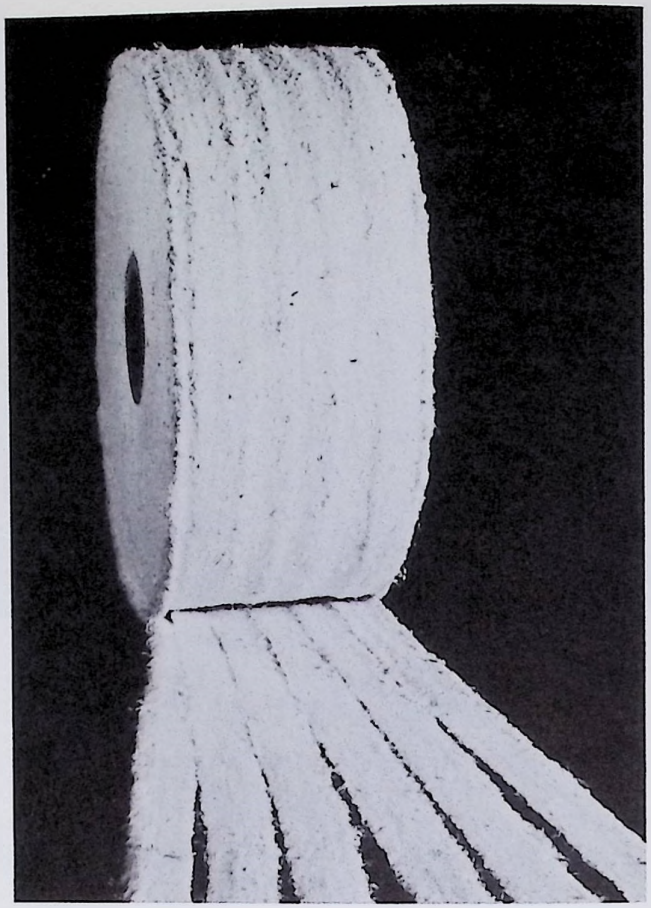
Carded asbestos fiber is 100% asbestos which has been fiberized by passing the crude through the several operations of the fiberizing process and by screening and carding. It is furnished in various qualities which are determined by the fiber length and type of crude asbestos used and by the operations 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 chrysotile asbestos fibers which have been blended with organic fibers. It is furnished in two styles: Style I, a single ribbon-like formation of fibers, and Style II, a paralleled assemblage of Style I lap.

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

Iron Content: Asbestos lap as made for the electrical industry is of two types with respect to iron content—ferrous and non-ferrous. Each of these conforms to A.S.T.M. requirements for maximum percentage of total iron and magnetic iron, as follows:

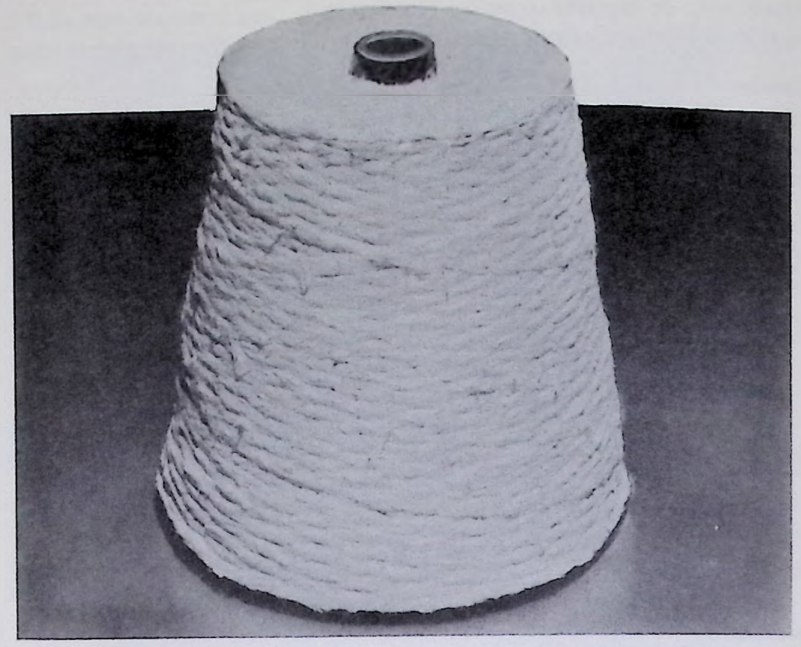
Type	Total Iron Content Max. Per Cent	Magnetic Rating Maximum
Ferrous	6	3
Non-Ferrous		
Underwriters' Grade	1.75	0.75
Grades A, AA and AAA	2	1

Standard Packages: Asbestos lap is packaged in rolls wound on paper tubes which vary in size in accordance with the number of slivers in the assemblage. (A sliver is approximately 1¼" wide.)

---

[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 56 and 57 of this Handbook.

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Asbestos Roving

Asbestos roving is an assemblage of carded chrysotile 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 four standard A.S.T.M. grades: Underwriters', A, AA and AAA. (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 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 pages 58 to 61.

Iron Content: Asbestos roving is of two types with respect to iron content—ferrous and non-ferrous. Each of these conforms to A.S.T.M. standards for maximum percentage of total iron and magnetic iron, as follows:

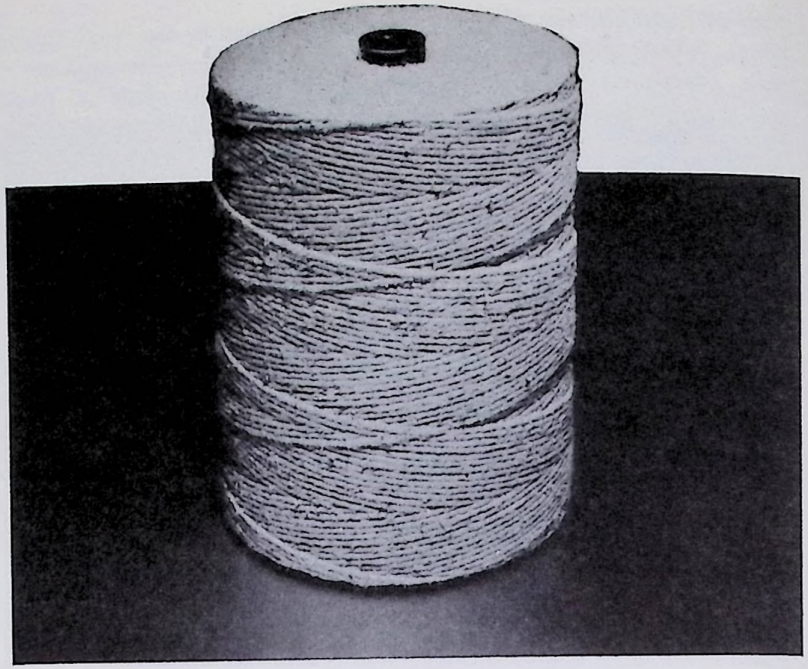
Type	Total Iron Content (Max. Per Cent)	Magnetic Rating (Maximum)
Ferrous	6	3
Non-Ferrous		
Underwriters' Grade	1.75	0.75
Grades A, AA and AAA	2	1

The non-ferrous type is generally specified where the roving is used over bare conductor. Ferrous roving is used where asbestos provides secondary insulation.

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



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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 styles 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 rayon, 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 diameter 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 or rayon, or a combination of both. 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.

* * * *

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[4] (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 pages 62 to 66.

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.)

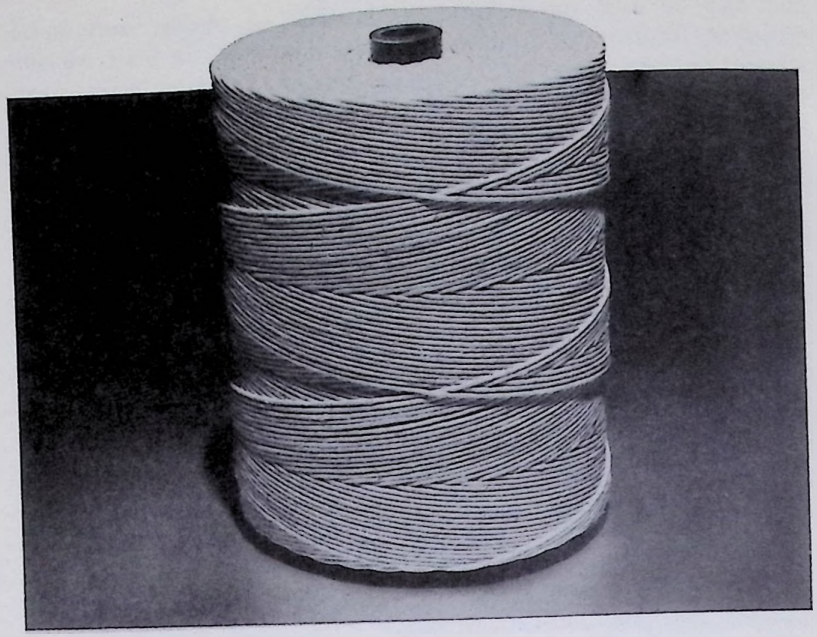
Direction Of Twist: Asbestos yarns are spun with "S" and "Z" twists. (See Glossary for definitions.)

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.

[4] 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.

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".

Iron Content: Asbestos cord is produced in two types with respect to iron content—ferrous and non-ferrous. Each of these conforms to A.S.T.M. standards for maximum percentage of total iron and magnetic iron, as follows:

TYPE	TOTAL IRON CONTENT (MAX. PER CENT)	MAGNETIC RATING (MAXIMUM)
Ferrous	6	3
Non-Ferrous		
Underwriters' Grade	1.75	0.75
Grades A, AA, AAA and AAAA	2	1

The non-ferrous cord is generally specified where exceptional electrical resistance is required.

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.

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Asbestos Thread

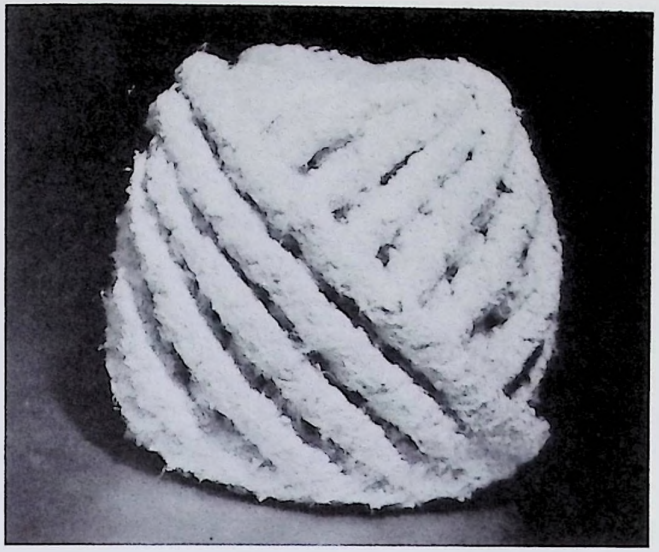
Asbestos thread is made by treating asbestos yarns with special compounds to lay the fibers and to produce an exceptionally smooth, uniform finish. It is produced in both plain (non-metallic) and metallic (wire-inserted) styles, the latter being noted for its great tensile strength and high thermal stability.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



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.

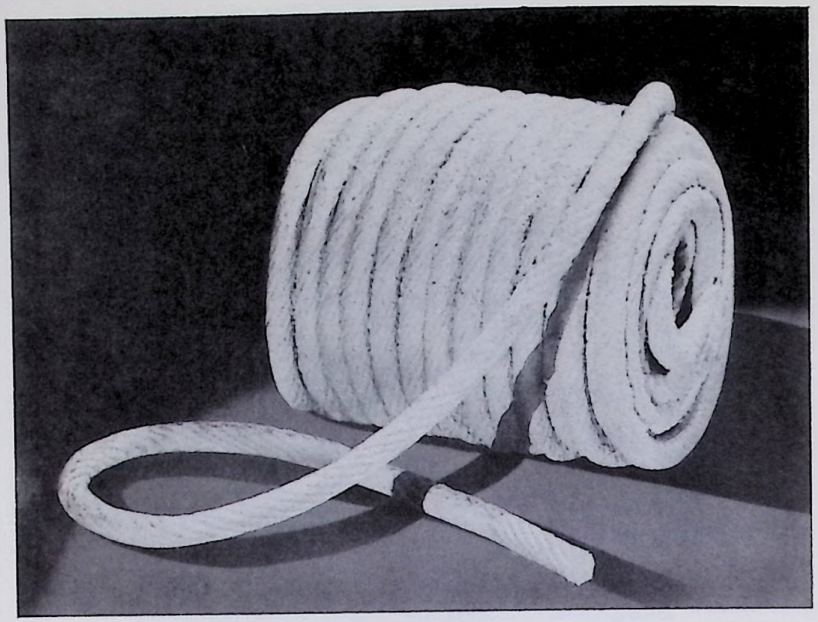
Specially designed asbestos wick is used to wipe excess metal from wire in the process of tinning and galvanizing and as a core for high temperature packings.

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 $\frac{3}{16}$" up to $\frac{7}{32}$" 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

filling for expansion joints in furnace brickwork, as a gasket for scaling 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 ⅛″ or 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 L—APPROXIMATE WEIGHTS AND FOOTAGES OF ASBESTOS ROPE

Nominal Diameter Inches	Approx. Lbs. per 100 Ft.	Approx. Ft. per Lb.
¼	2.4	41.7
⅜	5.0	20.0
½	9.5	10.5
⅝	13.7	7.3
¾	18.2	5.5
⅞	25.0	4.0
1	31.2	3.2
1¼	40.0	2.5
1½	48.0	2.1

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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.

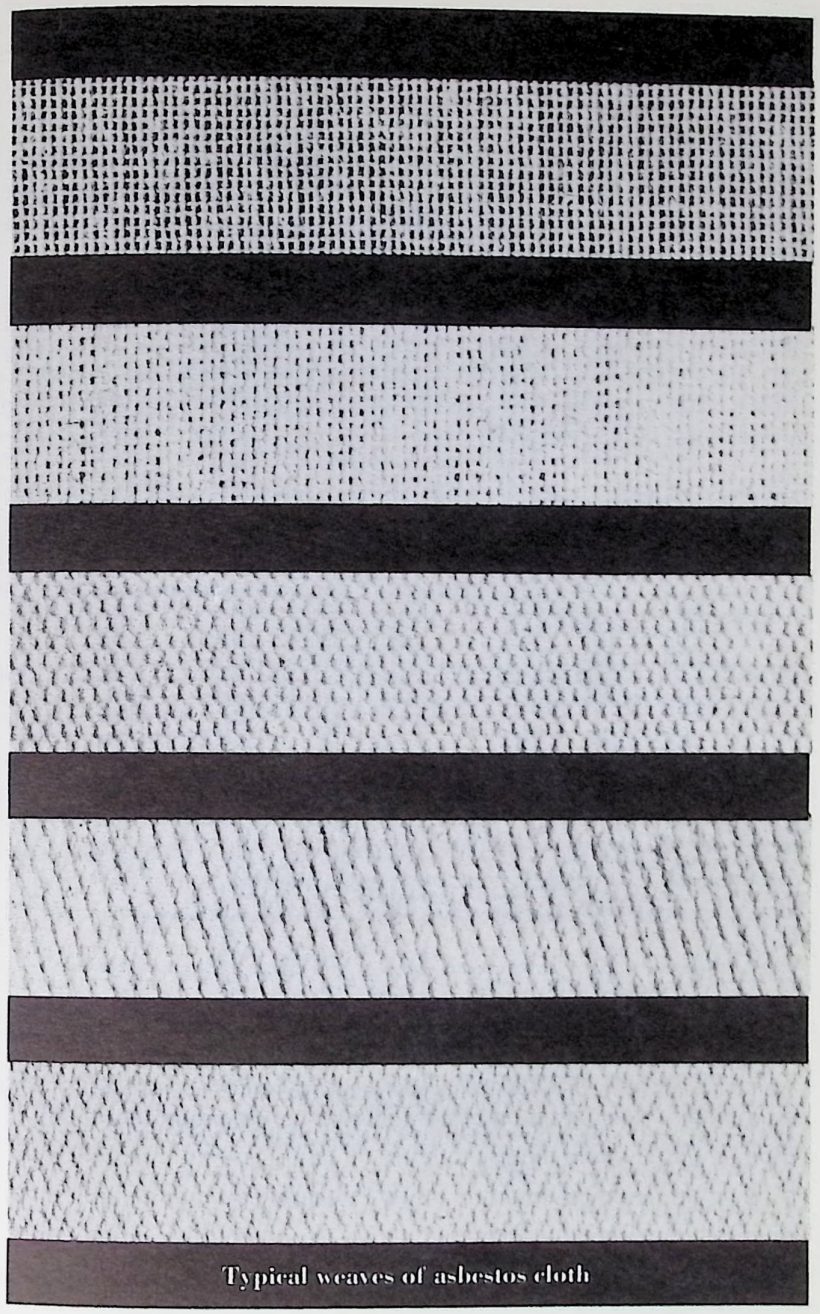
In addition to the standard asbestos cloths, specially treated cloths are made by most asbestos textile manufacturers to meet unusual conditions or where special characteristics such as resistance to extreme abrasion are required.

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 by personnel in the oil fields and the military services are another familiar application. Coats, trousers, aprons, shoes, gloves, mittens, leggings and helmets made of asbestos cloth are also extensively used to protect workers in industrial plants.

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, belts for blueprint and mat-drying machines and insulation for diesel exhaust pipes.

Federal 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 are often protected by a jacket of asbestos cloth.

The dust bags for removing dust, fumes and vapors in mechanical dust collecting systems are among the more specialized uses of asbestos cloth. Here, conditions of temperature, humidity and corrosion are such that often only bags made of asbestos cloth will satisfactorily meet the requirements of this exacting service. Other specialized applications are in the



Typical weaves of asbestos cloth

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glass industry, where treated asbestos cloths serve as paddle covers, tray linings and lehr curtains under extremely severe conditions.

In combination with other materials, asbestos cloth provides special advantages resulting from the inorganic mineral fibers of which it is woven. A typical example is in the fabrication of moulded and laminated plastics where asbestos fabrics, used as reinforcements, provide increased flexural and impact strength in the finished product.

The 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 and as an insulation over high temperature boilers and turbines.

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: The standard widths of asbestos cloth are 36" and 40" but 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 type of weave, grade of yarn used, its cut, ply, whether plain, reinforced or metallic and other factors. A selected list of asbestos cloths designed for general requirements and weighing from one-half to nearly five pounds per square yard, with construction details, thicknesses and grades available is shown in Table M.

Thicknesses: The thickness of single ply cloths ranges from approximately .015" to .100". Fabrics up to ½" 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 677.[5]

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

[5] See pages 67 and 68. For A.S.T.M. Specification D577 (standard methods of testing woven asbestos cloth) see pages 69 and 70.

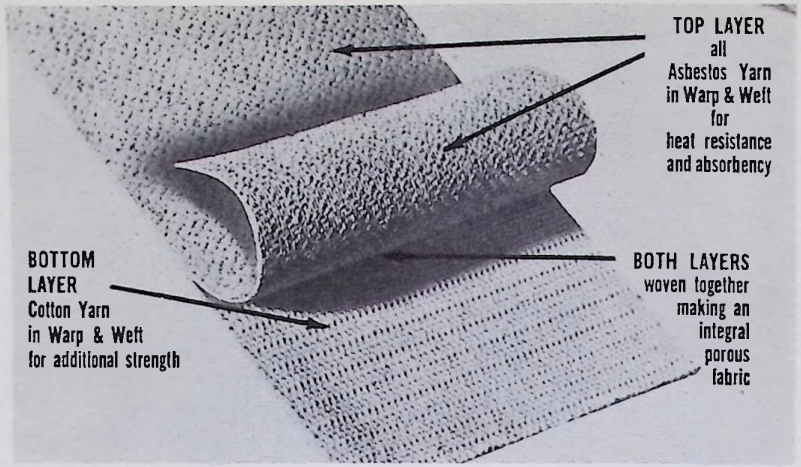
TABLE M—GRADES AND CONSTRUCTION OF TYPICAL ASBESTOS CLOTHS

(Thicknesses—after calendering)

Weight lbs/sq yd	ATI Style	Thickness (inches)	Ends/In. (Warp)	Picks/In. (Fill)	Warp Yarn	Filling Yarn	Grades*
PLAIN (Non-Metallic)							
.47	8P28	.015	21	16	2810	2810	U
.90	24BT090	.025	28	21	2410	3520	U
1.00	16P18	.035	16	13	1820	1810	U
1.05	17P24	.035	16	15	2420	2420	U
1.25	20P28	.036	27	13	2820	2820	U
1.30	21P10G	.035	16	9	1010	1010	U
1.30	21P14	.050	16	10	1420	1210	U
1.33	21P10	.055	8	8	1020	1020	C-U
1.35	21P16	.045	12	15	1620	1620	AA
1.37	22BT38	.034	30	28	3820	3820	U
1.40	22P16	.051	19	10	1620	1620	U-AAA
1.40	22P10G	.052	18	9	1010	1010	C-U
1.40	22P18	.045	24	15	1820	1810	U
1.45	23P18	.050	17	14	1820	1820	U
1.50	24P10	.055	9	9	1020	1020	U
1.50	24P18	.050	20	14	1820	1820	U
1.65	26P14	.053	14	14	1420	1420	U-AA
1.65	26P12	.050	12	12	1220	1220	U
1.75	28P16	.063	24	10	1620	1620	C-U
1.75	28P18	.060	26	13	1820	1820	U
1.80	29P10	.060	16	10	1020	1010	U
1.80	29P14	.058	20	10	1420	1420	C-U-AA
2.10	34P10	.062	16	9	1020	1020	C-U-AA
2.15	34P12	.062	20	10	1220	1220	C-U
2.25	36P10	.070	18	9	1020	1020	C-U-AA-AAA
2.40	38P12	.065	20	12	1220	1220	AAA
2.45	39P12	.075	27	9	1220	1220	AAA
2.45	39T12	.075	27	9	1220	1220	U-AA-AAA
2.50	40P10	.075	20	10	1020	1020	C-U-AA-AAA
2.50	40BT14	.070	27	14	1420	1420	C-U
2.50	40H14	.070	27	14	1420	1420	C-U
3.00	48P10	.080	18	9	1030	1020	C-U-AA-AAA
3.00	48T12	.075	30	10	1220	1220	C-U-AAA
3.33	53T12	.080	36	12	1220	1220	AAA-AAAA
3.65	58T12	.080	36	14	1220	1220	AAA
3.70	59T12	.080	40	14	1220	1220	AAAA
3.90	62T12	.085	24	9	1230	1230	AAA
4.75	76PIODC	.135	37	16	1020	1020	C-U
METALLIC (Brass Wire Inserted unless otherwise indicated)							
1.65	26M12	.040	16	9	1221	1211	C-U
2.00	32M12	.045	19	9	1221	1211	C-U
2.75	44M10	.062	18	9	1021	1021	C-U
3.00	48M8	.075	17	10	822	821	C-U
3.50	56M10	.070	18	9	1022	1022	C-U-AAA†

G—Glass Reinforced P—Plain Weave DC—Double Cloth
H—Herringbone Weave T—Twill Weave BT—Broken Twill
*See page 30 for explanation of Grades †Monel Wire (NiCu)

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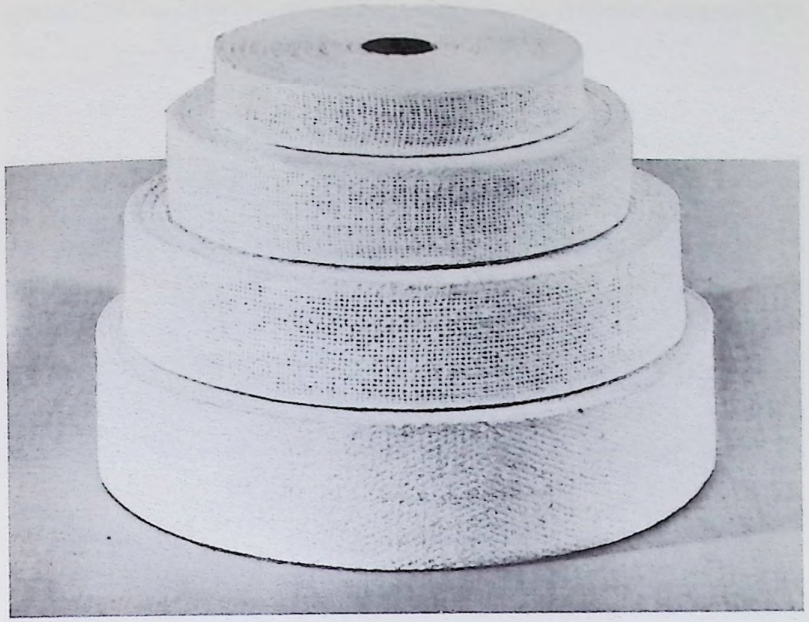
Asbestos Dryer Felts

THIS specialized product serves as a particular type of conveyor belting on paper machines, its function being that of a carrier for the moisture-laden web of paper as it passes around the series of drying cylinders on the machine. Its development is another example of how asbestos textiles have been successfully adapted to conditions that are highly destructive to textiles made of other fibers.

Formerly, dryer felts were usually made of all wool or all cotton yarns. However, under the deteriorating effects of the heat, moisture and acidity to which they are subjected, these felts made of organic fibers required frequent replacement.

About 25 years ago, one of the asbestos textile manufacturers succeeded in combining asbestos and cotton yarns in such a way as to provide a fabric with a complete and unbroken surface of asbestos. In the resultant product, called the asbestos dryer felt, this asbestos surface protects the felt from the heat of the dryers. Today this improved dryer felt, used in a majority of the paper mills in the United States and Canada, is providing from two to five times the service of the ordinary cotton felt. And because it is also superior in absorbency and porosity, its use helps assure faster, more even drying, better finish and increased production as well as substantial savings in replacement costs.

Woven on special looms, asbestos dryer felts can be produced in widths up to 320 inches and in lengths up to 500 feet to fit paper machines of any size. They are made in various weaves and weights to assure optimum performance under different operating conditions.



Asbestos Tape

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

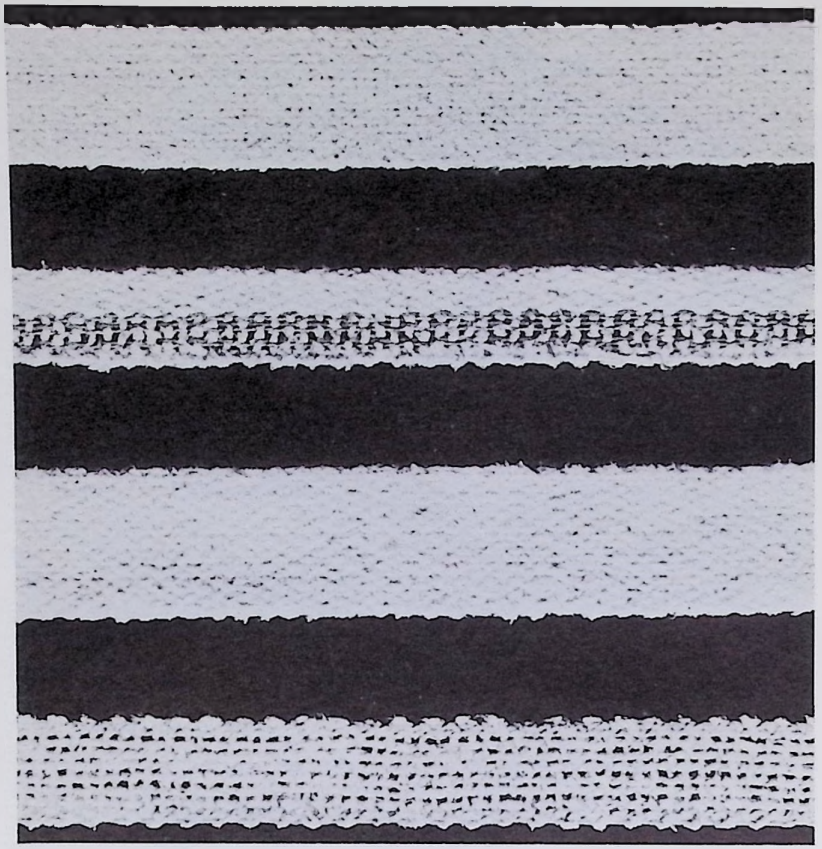
Uses: Asbestos tapes are widely used in the electrical industry as an insulation and have numerous other applications where an incombustible woven tape of high tensile strength and thermal stability is required.

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, oil-and-water-resistant wrapping for lead sheathed cables, as safety protection for covering hot piping such as used on steam locomotives, and as a component of packings and gaskets.

The metallic (wire-inserted) tapes are designed for use where the service requires higher tensile strength or a high coefficient of friction or where abrasive conditions are present. Large quantities are used as the major com-

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Asbestos oil burner wickings

ponent in woven brake linings and clutch facings. Asbestos tapes are woven with special alloy wires for applications where excessively high temperatures are encountered, as in the glass industry.

Special metallic tapes are made to serve as oil burner wicking. These are produced in many different designs to meet the requirements of the various types of burners in use and to provide for the proper vaporization of fuel, quick lighting and maximum efficiency in the operation of the burner.

The thermal stability of asbestos tape also adapts it particularly for use as a conveyor belting for carrying hot materials. Tapes for this purpose are made in both the plain and metallic styles. 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.

Another of the many specialized uses of asbestos tape is in the field of horticulture, where it serves for binding up the wounds of trees after grafting. Because asbestos tapes are inorganic and thus immune to bacterial attack, their use helps prevent infection and hastens healing.

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 in each grade.)

Thicknesses, Widths: The thinner plain tapes—those designed for electrical insulation— are woven in thicknesses from .010" to .030". 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.[6]

Weights: The weight of asbestos tape varies from fractions of a pound to more than 80 pounds per 100 feet, depending on size. Tables N and O show the approximate number of pounds per 100 feet and the approximate footages per pound of plain and metallic tapes of various thicknesses and widths.

Iron Content: Asbestos tape for electrical use is made in two types with respect to iron content—ferrous and non-ferrous. The non-ferrous tape is generally used for electrical applications where the tape acts as an insulator or where voltages and temperatures are extremely high. Both types conform to A.S.T.M. standards for maximum percentage of total iron and magnetic iron, as follows:

Type	Total Iron Content (Max. Per Cent)	Magnetic Rating (Maximum)
Ferrous	6	3
Non-Ferrous		
Underwriters' Grade	1.75	0.75
Grades A, AA, AAA and AAAA	2	1

Standard Packages: Asbestos tapes for electrical insulation are furnished in rolls wound on bushings. Rolls are of varying footage, depending on width and thickness. Packaging of tapes for other uses varies with the specific tape.

[6] For permissible variations in thickness, width, weight and construction, as well as other detailed information about asbestos tape not given above, see A.S.T.M. Specification D 315, reproduced on pages 71 to 74 of this Handbook.

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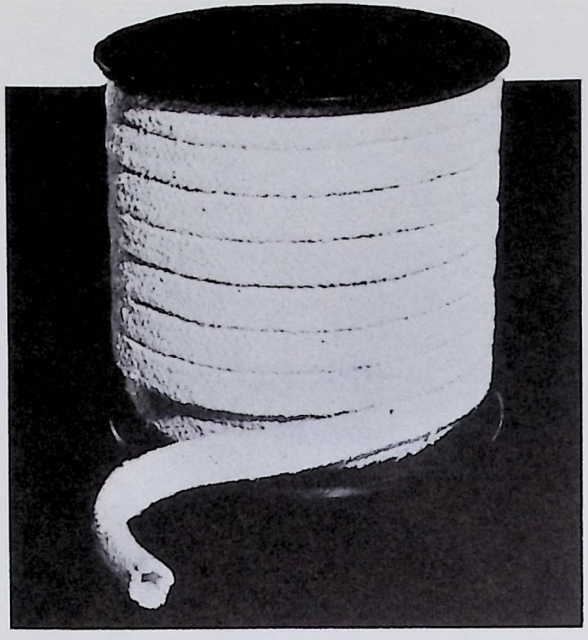
TABLE N—PLAIN WOVEN ASBESTOS TAPE

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

TABLE O—METALLIC WOVEN ASBESTOS TAPE

Thickness Inches	Width Inches	Approx. Ft. Per Lb.	Approx. Lbs. Per 100 Ft.
1/16	½	64.1	1.56
	¾	42.7	2.34
	1	32.0	3.12
	1¼	23.9	4.18
	1½	19.0	5.25
	2	15.1	6.62
	2½	12.1	8.26
	3	10.0	9.93
	3½	8.61	11.61
	4	7.55	13.24
	4½	6.71	14.90
	5	6.04	16.55
	5½	5.49	18.21
	6	5.03	19.87
⅛	¾	16.9	5.9
	1	12.7	7.9
	1¼	10.9	9.1
	1½	9.6	10.4
	2	6.6	15.2
	2½	5.6	17.9
	3	4.4	22.6
	3½	3.8	26.1
	4	3.4	29.5
	4½	3.0	33.0
	5	2.7	36.4
⅛	5½	2.5	39.9
	6	2.3	43.4
3/16	1	10.0	10.0
	1¼	8.0	12.5
	1½	6.5	15.3
	2	4.8	20.6
	2½	3.9	25.2
	3	3.3	30.3
	3½	2.8	35.3
	4	2.5	40.4
	4½	2.2	45.5
	5	2.0	50.5
	5½	1.8	55.5
	6	1.6	60.6
¼	1	7.1	14.1
	1¼	5.7	17.6
	1½	4.7	21.2
	2	3.5	28.3
	2½	2.8	35.4
	3	2.3	43.6
	3½	2.0	50.0
	4	1.8	56.3
	4½	1.6	62.6
	5	1.4	70.4
	5½	1.3	77.4
	6	1.1	83.7

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Asbestos Tubing

Asbestos tubing, sometimes called tubular sleeving, is made from asbestos yarns, either braided or woven to form a flexible sleeving or tubing. 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 unsized or with a finish coat of sizing to facilitate application if required. The woven style can be manufactured in various constructions and is usually made to specifications for each requirement.

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.

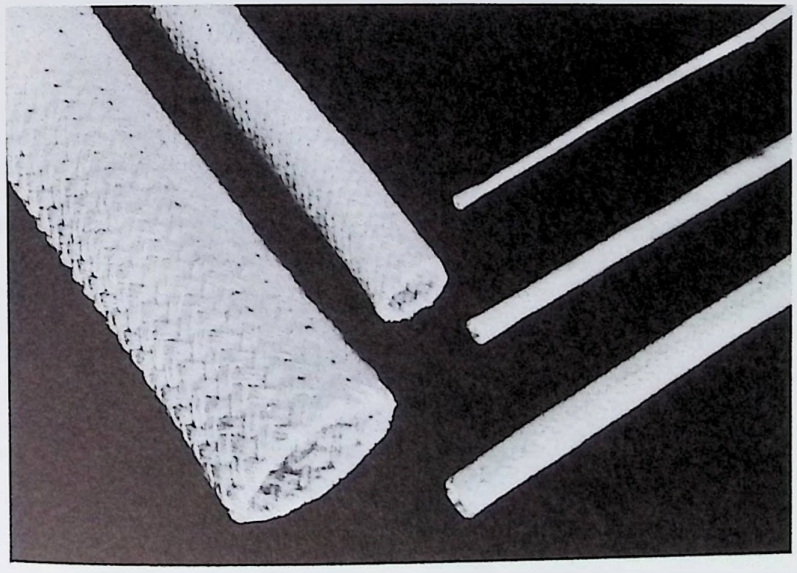
The woven style of asbestos tubing is particularly adapted for the insulation of bus bars, automobile heaters, as a flexible connection in hot air ducts and for other uses where a flexible woven type of sleeving is required. Woven tubing of large diameters is sometimes formed into the dust bags used in pneumatic systems for filtering hot waste gases which constitute a fire and dust hazard.[7]

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 of $\frac{1}{64}$" up to several inches. Wall thicknesses range from less than $\frac{1}{32}$" to approximately $\frac{1}{8}$". Woven tubings are made in diameters from less than 1" up to 22½".

Standard Packages: Braided tubing is packaged on spools, or wound on reels in quantities of 25 and 50 pounds. Woven tubing is sold in rolls, or cut to specified lengths.

[7] See also "Asbestos Cloth"



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TENTATIVE SPECIFICATIONS AND METHODS OF TEST

FOR

ASBESTOS LAP[1]

ASTM Designation: D 1061 - 52 T

ISSUED, 1949; REVISED, 1950, 1951, 1952.[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 lap, a felted asbestos product. Lap is identified by the type, weight in grains per linear yard, and the width, which shall be specified on the order.

Styles and Types

2. (*a*) *Styles.*—Asbestos lap is produced in two styles as follows:

Style I is a ribbon-like formation of felted asbestos fibers.

Style II is a paralleled assemblage of style I lap.

(*b*) *Types.*—There are two types of asbestos lap: ferrous and non-ferrous.

Definition

3. *Standard Condition.*—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 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 purposes of tests, it is recognized that specimens reach moisture equilibrium after exposure for at least 4 hr. unless otherwise specified, under the above conditions.

Grades

4. (*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.

Iron Content

5. Asbestos lap shall conform to the following requirements for total iron content and magnetic ratings:

Type	Total Iron Content, max., per cent	Magnetic Rating, max.,
Ferrous lap	6	3
Non-ferrous lap:		
Underwriters' Grade	1.75	0.75
Grade A, AA, and AAA	2	1

Weight

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

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

METHODS OF TESTING

Sampling

7. (*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

8. All test specimens shall be brought to standard condition in accordance with Section 3 prior to testing and all tests shall be made under standard 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[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 of that lot or unit.

Total Iron Content

10. The total iron content shall be determined in accordance with Method A of the Standard Specifications and Methods of Test for Asbestos Roving for Electrical Purposes (A.S.T.M. Designation: D 375).

Weight

11. From each of five packages selected in accordance with Section 7, 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 Iron Rating

12. The magnetic iron rating shall be determined in accordance with Tentative Method of Test for Magnetic Rating of Asbestos Used for Electrical Purposes (A.S.T.M. Designation: D 1118).

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

[2] Latest revision accepted by the Society at annual meeting, June, 1952.

[a] This factor is based upon a proved average of 14 per cent water of crystallization in chrysotile asbestos.

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STANDARD SPECIFICATIONS AND METHODS OF TEST FOR ASBESTOS ROVING FOR ELECTRICAL PURPOSES[1]

ASTM Designation: D 375 – 52

ADOPTED, 1936; REVISED, 1937, 1941, 1942, 1944, 1949, 1952.[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.

Scope

1. (*a*) 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*).

(*b*) Roving, in the asbestos textile industry, is an assemblage of carded fibers rubbed into a single strand without twist.

Definitions

2. (*a*) *Asbestos Roving.*—Asbestos roving is composed of a mixture of chrysotile asbestos and cotton or other organic fiber.

(*b*) *Reinforced Asbestos Roving.*—Reinforced asbestos roving is composed of a core of yarn consisting of organic fiber, covered with a mixture of chrysotile asbestos and organic fiber.

[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committe 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.

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

A "tentative revision" of this standard appears on p. 61

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

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

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
Commercial Grade	75 to 80 per cent, excl.
Underwriters' Grade	80 to 85 per cent, excl.
Grade A	85 to 90 per cent, excl.

NOTE.—The 16 and 18 cut rovings are available only in Commercial and Underwriters' grades; all other cuts are available in all three grades.

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

Iron Content

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

	Total Iron Content, max., per cent	Magnetic Rating, max.,
Ferrous roving	6	3
Non-ferrous roving:		
Underwriters' Grade	1.75	0.75
Grade A	2	1

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.*—Ten determinations of the number of yards per pound shall be made 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 (*a*).

(*b*) *Procedure.*—The packages shall be grouped on the floor and five strands shall be drawn from them slowly, looping over a support to assemble 20 strands, which shall be cut into a 1-yd. length while suspended. The 20 yd. shall be weighed to the nearest 0.1 grain and the number of yards per pound calculated

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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. Two specimens, weighing not less than 5 g. each shall be taken from each lot or unit sampled 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 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[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 two determinations made on the specimens from a given lot or unit shall be the asbestos content of that lot or unit.

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.

TOTAL IRON CONTENT

Test Specimens

10. One specimen, weighing not less than 1 g. shall be taken from each sample and the average of the total iron content determinations, shall be taken as the accepted determination.

Reagents

11. (*a*) *Stannous Chloride Solution.*—Dissolve 15 g. of c.p. tin in 350 ml. of hot HCl (sp. gr. 1.19) and dilute to 1 liter.

NOTE.—A more convenient alternative method of preparing this solution is as follows: Dissolve 14.5 g. of stannous chloride in 165 ml. of HCl (sp. gr. 1.19) and dilute to 500 ml. This solution should be kept in a tightly-stoppered bottle in contact with a stick of metallic tin in order to prevent oxidation. One milliliter of this solution will reduce about 0.015 g. of ferric iron to the ferrous state. The concentration of this solution will naturally increase as the tin dissolves in the acid liquor.

(*b*) *Mercuric Chloride Solution.*—Prepare a saturated solution containing 60 to 100 g. of $HgCl_2$ per liter. Approximately 1.2 ml. of this solution will oxidize the tin in 1.0 ml. of the original strength stannous chloride solution.

(*c*) *Diphenylamine Indicator.*—Dissolve 1 g. of diphenylamine in 100 ml. of H_2SO_4 (sp. gr. 1.84).

(*d*) *Potassium Dichromate (0.1 N).*—Prepare a solution of potassium dichromate of approximately 0.1 N strength as follows: Dissolve 4.9 g. of pure $K_2Cr_2O_7$ in distilled water and dilute to 1 liter. Allow to stand several hours and then standardize against a solution containing a known amount of iron in accordance with the procedure given in Section 12.

(*e*) *Hydrochloric Acid (1:1).*—Mix equal volumes of HCl (sp. gr. 1.19) and distilled water. Each sample will require 50 ml. of this solution.

Procedure

12. *Total Iron.*—Dry a sample of approximately 1 g. to constant weight in an oven at 105 to 110 C., transfer the specimen to a desiccator, allow to cool to room temperature, and then reweigh. This is the oven-dry weight of the specimen, weight W. Heat the specimen gently with a bunsen burner to smoke off organic matter and then ignite in a muffle at 650 C. for 20 to 30 min. Transfer the specimen to a 200-ml. porcelain casserole and digest with 50 ml. of HCl (1:1). Without filtering, reduce the ferric iron in this hot solution by adding the stannous chloride solution drop by drop from a buret until the yellow color of the $FeCl_3$ just disappears. The white surface of the porcelain casserole affords a convenient background for determining when sufficient stannous chloride has been added. Cool the solution to 15 C. and while stirring, add 10 ml. of $HgCl_2$ solution. The formation of a light silky precipitate indicates that the conditions are correct. If a dark precipitate of metallic mercury is formed, it indicates that an excess of stannous chloride has been added and the determination shall be repeated using the correct amount of the reducing reagent. Stir the solution vigorously for 1 min., add 3 drops of indicator solution, and dilute to 150 ml., with cold distilled water. Titrate with standard 0.1 N $K_2Cr_2O_7$ having a titer no greater than 0.004 g. of Fe_2O_3. The end point is reached when a drop of the potassium dichromate solution produces an intense deep-blue coloration that remains unchanged on the further addition of dichromate.

Calculation and Report

13. Report the total iron as a percentage of the weight of the oven-dried specimen as calculated from the following formula:

$$\text{Total iron per cent} = \frac{M \times N \times 0.05584}{W} \times 100$$

where:

M = milliliters of the standard $K_2Cr_2O_7$ solution,
N = normality of the standard $K_2Cr_2O_7$ solution, and
W = weight of the original specimen.

MAGNETIC IRON RATING

Procedure

14. The magnetic rating shall be determined by the Mapes method on one specimen taken from each sample and the average shall be taken as the accepted determination.

[a] This factor is based upon a proved average of 14 per cent water of crystallization in chrysotile asbestos.

EDITORIAL NOTE

The following "tentative revision" of this standard has been accepted by the Society for the purpose of eliciting criticisms of which due cognizance will be taken before the revision is approved for incorporation in the standard. Criticisms should be addressed to the Society, 1916 Race St., Philadelphia 3, Pa.

Section 4.—Change the asbestos content requirements to read as follows:

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.

Also revise the note in this section to read as follows: "Note.—The 16 and 18 cut rovings are available only in the Underwriters' Grade; all other cuts are available in all four grades."

Section 5.—In the table following Grade A, add "AA, and AAA."

Section 9.—Designate the present text as Paragraph (*a*) and add as Paragraph (*b*) the following:

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

Tentative revision issued June, 1952.

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TENTATIVE SPECIFICATIONS AND METHODS OF TEST FOR ASBESTOS YARNS[1]

ASTM Designation: D 299 – 52 T

ISSUED, 1948; REVISED, 1949, 1950, 1951, 1952.[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 define asbestos yarn, prescribe the methods of testing, and stipulate tolerances.

Definitions

2. (*a*) *Asbestos Yarn.*—Asbestos yarn is yarn consisting 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 is yarn consisting of: (*1*) asbestos fiber, or (*2*) asbestos and other fibers.

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

(*d*) *Reinforced Asbestos Yarn.*—Reinforced asbestos yarn is plain yarn 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 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., unless otherwise specified, under the above conditions.

(*f*) *Direction of Twist.*—The direction of twist shall be as defined in the Standard Definitions of Terms Relating to Textile Materials (A:S.T.M. Designation: D 123), as follows:

Twist, Direction of.—A yarn or cord has S twist if, when held in a vertical position, the spirals conform in direction of slope to the central portion of the letter "S," and Z twist if the spirals conform in direction of slope to the central portion of the letter "Z."

(*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 × 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, incl., have 3-digit construction numbers; yarns comprising 10-cut to 50-cut, incl., 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

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.

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

(*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 minus 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

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

[2] Reverted to tentative and revised by action of the Society at annual meeting, June, 1948.

Latest revision accepted by the Society at annual meeting, June, 1952.

Prior to their present publication as tentative, 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.

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from the size specified by more than plus or minus 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 tension testing machine conforming to the Standard Specifications for Textile Testing Machines (A.S.T.M. Designation: D 76).

(*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 $12 \pm \frac{1}{2}$ 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 $\frac{1}{2}$ 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 by the following formula:

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

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:

$$Y = \frac{7000 \times 30 \times (\text{number of plies})}{W \times 0.90}$$

where:

Y = yards per pound of single ply, and

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

Note.—The factor 0.90 in the formula compensates for an assumed contraction of 10 per cent incurred in twisting.

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

$$Y = \frac{7000 \times 30 \times (\text{number of plies})}{W \times 0.90}$$

where:

Y = yards per pound, and

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

Note.—The factor 0.90 in the formula compensates for an assumed contraction of 10 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

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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 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 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 is to be computed on the basis of the oven-dry weight of the glass reinforced yarn previous to removal of the glass yarn insert.

[a] This factor is based upon a proved average of 14 per cent water of crystallization in chrysotile asbestos.

Standard Specifications for
WOVEN ASBESTOS CLOTH[1]

ASTM Designation: D 677 - 50

ADOPTED, 1950.[2]

This Standard of the American Society for Testing Materials is issued under the fixed designation D 677; 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 apply to plain weave asbestos cloth in a weight range of 1.00 to 3.10 lb. per sq. yd. and in widths of 36 and 40 in.

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.

Grades

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.

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

[2] Prior to adoption as standard, these specifications were published as tentative from 1942 to 1949.

Physical Properties

4. The physical properties of asbestos cloth in widths of 36 and 40 in. shall conform to the requirements prescribed in Table I, subject to the tolerances specified in Sections 5 to 10. The available grades are also shown in Table I.

TABLE I.—PHYSICAL PROPERTIES AND AVAILABLE GRADES OF ASBESTOS CLOTH.

Weight, lb. per sq. yd.	Thickness,[a] in.	Construction, yarns per in.		Yarn Number		Available Grades				
		Warp	Filling	Warp	Filling	Commercial	Underwriter's	A	AA	AAA
1.00	0.030	16	13	18/2	18/1		X			
1.05	0.030	21	15	28/2	28/2		X			
1.25	0.035	28	15	28/2	28/2		X			
1.35	0.040	16	14	18/2	18/2		X			
1.50	0.050	20	14	18/2	18/2		X			
1.65	0.055	14	14	14/2	14/2	X	X	X	X	X
1.75	0.060	26	13	18/2	18/2	X	X			
1.80	0.063	20	10	14/2	14/2	X	X	X	X	X
2.15	0.065	20	10	12/2	12/2	X	X	X	X	X
2.25	0.070	18	8	10/2	10/2	X	X	X	X	X
2.50	0.075	20	9	10/2	10/2	X	X	X	X	X
3.10	0.100	18	9	10/3	10/2	X	X	X	X	X

[a] The thickness as indicated applies to Commercial and Underwriters' grades only. It does not apply to grades with higher asbestos content, due to manufacturing variables not introduced in Commercial and Underwriters' grades.

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Tolerances

Width

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

Weight

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

Thickness

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

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

Construction

8. The number of warp ends or filling picks per inch of asbestos cloth shall not vary by more than 1 end or 1 pick over or under the specified warp or filling counts.

Yarn Number (Cut)[2a]

9. The yarn number (cut) of the yarns in asbestos cloth shall not vary from that specified by more than the following permissible variations:

[2a] This table was editorially revised in 1951.

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

Asbestos Content

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

Methods of Testing

Methods of Testing

11. The properties enumerated in these specifications shall be determined in accordance with the Standard Methods of Testing Woven Asbestos Cloth (A.S.T.M. Designation: D 577) of the American Society for Testing Materials.

APPROVED AS
AMERICAN STANDARD
BY THE AMERICAN STANDARDS ASSOCIATION
ASA NO.: L14.35

Standard Methods of

TESTING WOVEN ASBESTOS CLOTH[1]

ASTM Designation: D 577 – 52

Adopted, 1942; Revised, 1952.[2]

This Standard of the American Society for Testing Materials is issued under the fixed designation D 577; 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 untreated crysotile asbestos cloth over 12 in. in width of the following grades:

Grade	Asbestos Content, per cent
Commercial Grade	75 to 80, excl.
Underwriter's 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.

Sampling

2. (*a*) At least one sample shall be taken at random from each 10 rolls or fraction thereof so as to be representative of the lot.

(*b*) From each roll selected in accordance with Paragraph (*a*), test specimens shall be taken the full width of the cloth and shall be approximately 1 sq. yd. in area.

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.

Width

4. The width of the cloth shall be determined in accordance with Section 4 of the Standard General Methods of Testing Woven Fabrics (A. S. T. M. Designation: D 39) of the American Society for Testing Materials.

Thickness

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

[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 a tentative from 1940 to 1942.

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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

6. (*a*) The specimens for the determination of weight shall be taken in accordance with Section 2 (*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.

Count, Warp and Filling

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

Breaking Strength

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

Asbestos Content

9. The asbestos content shall be determined in accordance with Section 23 of the Standard Specifications and Methods of Test for Asbestos Tape for Electrical Purposes (A. S. T. M. Designation: D 315) of the American Society for Testing Materials.

STANDARD SPECIFICATIONS AND METHODS OF TEST FOR ASBESTOS TAPE FOR ELECTRICAL PURPOSES[1]

ASTM Designation: D 315 – 52

ADOPTED, 1933; REVISED, 1936, 1937, 1941, 1944, 1949, 1952.[2]

This Standard of the American Society for Testing Materials is issued under the fixed designation D 315; 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 and methods of test apply to asbestos tape woven from plain asbestos yarn and suitable for electrical purposes.

TOLERANCES

Tolerances

2. Tolerances are the limits within which the specified characteristics of the tape must come to constitute a good delivery on contract.

Width

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

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

Thickness

4. The average thickness of the tape shall not vary from that specified by more than plus or minus 0.003 in.

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

[2] Prior to adoption as standard, these specifications were published as tentative from 1929 to 1933, being revised in 1931.

Weight

5. The average weight of the tape shall be calculated in yards per pound and shall be not less than the following:

Thickness, in.	Width, in.	Weight, min., yd. per lb.
0.015	½	85
	¾	65
	1	50
	1½	40
	1½	30
0.020	½	70
	¾	53
	1	40
	1½	32
	1½	25
0.025	½	45
	¾	35
	1	25
	1½	18
	1½	13
0.030	1	17
	1½	13½
	1½	11

Weave

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

Construction

7. The number of ends and picks per inch shall conform to the following re-

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quirements within plus 6 or minus 2 ends, and plus 5 or minus 1 pick:

Thickness, in.	Ends per Inch	Picks per Inch
0.015	30	18
0.020	22	18
0.025	27	12
0.030	27	12

Breaking Strength

8. The breaking strength per inch of width of each specimen of the tape tested shall be not less than the following requirements:

Thickness, in.	Breaking Strength, min., lb. per in. of width Before Heating	After Heating
0.015	30	15
0.020	35	15
0.025	50	25
0.030	85	43

Electrical Properties

9. The number of conducting particles in a 10-yd. length of tape of 0.015 in. in thickness shall not exceed 100 per inch of width. This requirement applies to 0.015-in. type only.

Asbestos Content

10. 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.

Sizing

11. No sizing shall be used.

Workmanship

12. 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

13. The tape shall be calendered.

Rolls

14. (*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 $\frac{3}{8}$ in. 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 rolls shall each 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 end of the tape shall be firmly secured. Metallic fasteners are not acceptable.

Methods of Testing

Sampling Rolls for Test

15. From each shipment of tape at least three rolls shall be selected and the tests prescribed shall be made on sample lengths cut 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.

Test Condition

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 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.

Width

17. (*a*) The width shall be determined by the use of a standar steel scale so graduated as to obtain the degree of accuracy specified in Section 3. 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 yd. apart in any one roll, and the average of the measurements shall be accepted as the width of the lot under test.

Thickness

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

(*b*) The thickness shall be taken as the average of ten measurements at ten different places on the sample not less than 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 12 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 shall be determined in a length of 1 in.

(*c*) *Number of Tests.*—The number of ends shall be taken as that secured by making one determination per sample. The number of picks per inch shall be taken as the average of five counts made at five different places on the sample. An accepted thread counting magnifying glass shall be used in making the counts.

Breaking Strength

21. (*a*) The breaking strength of the tape shall be determined on a testing machine conforming to the Standard Specifications for Textile Testing Machines (A.S.T.M. Designation: D 76) of the American Society for Testing Materials.

(*b*) Tests shall be made in the direction of the warp only. The specimens shall be tested in full section. The initial length of the test specimens between the clamps shall be 3 in. and the speed of the pulling clamp shall be 12 $\pm$ $\frac{1}{2}$ in. per min.

(*c*) *Breaking Strength After Heating.*—The breaking strength after heating shall be determined on specimens which have been heated in an oven for 5 min. at 300 C. (570 F.).

(*d*) *Number of Tests.*—The breaking strength before and after heating shall each be determined on five specimens taken from each sample roll. No single test shall fall below the requirements prescribed in Section 8.

Electrical Properties

22. The test for conducting particles shall be made by passing the tape at a rate of 2 yd. per minute under a pressure of 7 lb. per inch 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. The tests shall be made on a 10-yd. length in each of the sample rolls, and the average of the determinations shall be taken as the number of conducting particles.

Asbestos Content

23. One test specimen, weighing not

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less than 5 g. shall be taken from each sample roll, 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 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[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 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.

[a] This factor is based upon a proved average of 14 per cent water of crystallization in chrysotile asbestos.

GLOSSARY

ASBESTOS, CHRYSOTILE—A hydrated silicate of magnesium.

ASBESTOS, FERROUS—Asbestos having a maximum total iron content of 6%.

ASBESTOS, NON-FERROUS—Asbestos having a maximum total iron content of 1.75% (Underwriters' Grade).

CLOTH, METALLIC—A woven fabric of metallic asbestos yarn.

CLOTH, PLAIN—A woven fabric of plain asbestos yarn.

CORD, BRAIDED—A cord with a yarn core and one or more braided jackets.

CORD, TWISTED—A uniform strand of asbestos made by twisting several ends of either single or plied yarn.

CUT—A term indicating the number of a yarn or roving. The word "cut" preceded by a number indicates, in multiples of 100 yards, the yardage per pound of a single yarn or roving.

DRYER FELT—An asbestos faced belt for conveying paper over hot dryer rolls.

ENDS—Strands of yarn in the warp (usually per inch).

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

GRADE—Classification determined by the percentage of asbestos by weight of an asbestos textile product.

LAP—A felted asbestos product with a ribbon-like formation, or a paralleled assemblage of a ribbon-like formation of felted asbestos fibers.

LISTING—An obsolete term for tape.

PICKS—Strands of yarn in the filling or woof (usually per inch).

ROPE—A stranded product of several ends of wick.

ROVING—An assemblage of carded fibers rubbed into a single strand without twist.

ROVING, CORE—Same as Inserted Roving.

ROVING, INSERTED—An assemblage of carded fibers rubbed into a single strand without twist and containing one or more ends of reinforcing yarn in the center.

ROVING, REINFORCED—Same as Inserted Roving.

SLEEVING—Same as Tubing.

SLIVER—The single-end delivery of a carding machine.

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SLUBBING—A large condensed roving.

STANDARD CONDITION—That reached by an asbestos textile product when in moisture equilibrium with a standard atmosphere having a relative humidity of 50% at 70 F.

TAPE, METALLIC—A narrow woven fabric of metallic yarn with selvage edges.

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

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

TUBING—A braided or woven tube of asbestos yarn.

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".



WICK—A twisted product of multiple ends of roving or slubbing.

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

YARN, ENDLESS—Any type of plain yarn, plied or single, in which all splices are made without knots.

YARN, HIGH TENSILE—A superior quality yarn with higher than average strength.

YARN, INSERTED—Same as Reinforced Yarn.

YARN, METALLIC—A yarn consisting of plain asbestos yarn with an insert of brass, copper or other fine wire.

YARN, PLAIN—A yarn consisting of asbestos fibers, or asbestos and other fibers.

YARN, PLIED—A number of strands of single asbestos yarn twisted together to form a heavier yarn.

YARN, REINFORCED—A yarn consisting of asbestos fibers or asbestos and other fibers, with an insert of yarn made of other fibers.

YARN, SIZED—Same as Treated Yarn.

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.

YARN, WIRE-INSERTED—Same as Metallic Yarn.

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