B-1

THE ORIGIN OF ASBESTOS

(Extracted from "The Origin of Asbestos," by M. F. Smith, Research Chemist, Philip Carey Corporation; published in ASBESTOS, July, 1940.)

Chemical and mineralogical studies clearly show that asbestos fiber is not of vegetable or animal origin, but is entirely of mineral origin. Taking as an example the Chrysotile asbestos mined in Canada, the observed facts lead to the following explanation of its formation.

In the greenstone region of Canada, covering hundreds of square miles, the present surface rock was at one time thousands of feet below its present elevation and under very great pressure due to the weight of the overlying rock and soil. This rock is a variety of olivine called peridotite and is composed of iron, magnesia and silica. In certain extensive areas this rock was acted on by hot ground waters, under high pressure, and carrying dissolved salts and carbon dioxide. The pressure is easily understood when it is realized that the rock was very far below the earth's surface, and the high temperature is explained by the fact that the temperature of the earth increases about 1°F for every 50 feet of depth. From depth alone, this would give a temperature increase of at least 20°F for every 1,000 feet, not even considering the hot intrusive rocks also present. These ground waters gradually changed the original rock from the iron-containing peridotite to the magnesia-silica-water ($3MgO \cdot 2SiO_2 \cdot 2H_2O$) mineral – Serpentine. During the alteration the volume of the rock increased, causing innumerable small and large cracks. These cracks were filled with the hot ground waters, chiefly derived from the slow infiltration of rain or surface waters. This underground water circulated through the cracks in the rock, descending slowly through the smaller openings in the rocks and ascending through the larger openings and cracks. This water at high temperature and containing carbon dioxide under pressure is a very good rock solvent. The water rising in the larger cracks loses pressure and slowly cools, losing some of its solvent power and throwing out a small amount of the dissolved rock. This material deposits on the sides of the crack in the rock through which the water is flowing and, if suitable mineralizers are present, such as dissolved salts and carbon dioxide, tends to form regular crystal shapes, depositing the molecules in a regular rather than a haphazard manner. Rock salt forms in cubes; diamond forms in octahedrons; graphite in six-sided plates; gold in octahedrons or cubes. Asbestos forms in easily separable, closely-packed filaments, which when teased apart give the workable form in which asbestos is marketed and used.

The theory for the formation of asbestos fiber as given in the foregoing is held by many experts, but may be, and is, contested in some of its minor details by others, based on slightly different conditions present where they made their observations. In most cases the difference of opinion relates to such details as to how the waters were heated and what the mineralizers were rather than to the whole of the theory. What has been said above about Canadian asbestos fiber formation holds also for the Vermont Chrysotile fibers and Russian, Cyprus and South African Chrysotile fibers, as well as for some of the other non-Chrysotile types.

TERSE ASBESTOS FACTS

Δ "Asbestos" is not the name of a distinct mineral species but is a commercial term applied to fibrous varieties of several minerals differing widely in chemical composition, the fibers being diverse in length, strength, flexibility and consequent usefulness.

Δ The properties of asbestos that give it commercial value are its fibrous structure, the great strength of its fibers and its resistance to high temperatures and to certain types of chemical attack.

Δ Grading of asbestos fiber is on the basis of length rather than quality. Fibers of the same *quality* vary in price according to length, the longer fibers being more expensive.

Δ The varieties of asbestos most used commercially are Chrysotile, Amosite, Crocidolite (Blue) and Anthophyllite. Chrysotile is of the Serpentine group and the other varieties (Crocidolite, Amosite, Anthophyllite, Tremolite and Actinolite) are of the Amphibole group of fibers. The Amphibole fibers are more brittle than Chrysotile fibers and have a "harsh" texture. Chrysotile, both long and short fiber, makes up the bulk of world production and use, although there is a substantial demand for Amosite and Blue and a limited usage of Anthophyllite and Tremolite.

Δ Chrysotile asbestos excels commercially due to its fineness of fiber, high flexibility, good heat resistance, general workability and ample supply. The longer fibers can be spun easily into textile materials. The "harsh" fibers of the Amphibole group are well suited for use in materials based on wet processing such as asbestos-cement products where harshness becomes an aid to filtration and rapid water release.

Δ Crocidolite and Amosite asbestos fibers are highly acid-resistant, making them particularly valuable for use in chemical plant applications.

Δ Amosite is the longest of all asbestos fibers. It is used in the manufacture of thermal and acoustical insulation, textiles, asbestos-cement pipe and sheets, reinforced plastics, asbestos paper products, sprayed insulation, pipe-line coatings, fire-rated door cores and various specialty insulations. The most important insulation products in which Amosite is used are rigid, molded pipe insulations and the block or "slab" insulations used for high-temperature service.

Δ Normal end-use applications for Crocidolite include textiles for chemical packings and gaskets, mats and saturated paper for reinforced plastic laminates, non-woven felts for fire protection, filtration media for chemicals and air-borne radioactive particles, reinforcements for asbestos-cement pipe and sheets, marine bulkhead materials, friction materials, and reinforcements for pre-mix and dough molding compounds.

Δ Anthophyllite and Tremolite fibers are too brittle to be spun or used as fibrous reinforcements but, because of their resistance to attack by certain chemicals, are used for filtering purposes in chemical processing plants and in laboratories.

Δ The earliest use of asbestos known to the world was over 2,000 years ago when the Romans used asbestos cloth for the wrapping of their dead–in the cremation process.

Δ The earliest records of the Asbestos Industry indicate asbestos (Chrysotile) was first "discovered" in North America in 1860 in the Des Plantes River region of the Province of Quebec, Canada. The deposits at Thetford and Coleraine were not commercially recognized until 1877, or later. However, there is every reason to believe asbestos was known in Canada at least 136 years earlier. According to a letter dated June 2, 1725, written by Benjamin Franklin to Sir Hans Sloane, a distinguished naturalist and collector, asbestos was actually known in Canada as early as 1724 (probably by the Indians). The story brings out an interesting point in Asbestos history. In the letter, Franklin wrote:

"Having lately been in the northern parts of America, I have brought from thence a purse made of the stone asbestos . . . ."

In his autobiography, Franklin again refers to the purse, i.e., "I had brought some curiosities with me from America, the principal of which was a purse made of the stone asbestos, which fire only purifies. Sir Hans Sloane, hearing of it, called upon me and invited me to his home in Bloomsbury Square [England], where, after showing me everything that was curious, he prevailed upon me to add this piece to his collection for which he paid me handsomely."

By "northern parts of America" we can easily assume Franklin meant Canada. Since the letter was written in 1725 and (according to his autobiography) Franklin arrived in London on December 24, 1724, and had the purse with him, we can again safely assume he had acquired it very early in 1724–in those days it took several months to traverse the Atlantic Ocean from America to England. Following the death of Sir Hans in 1753, the asbestos purse, as part of his collection, was bequeathed to the British nation and the entire collection was opened to the public at Bloomsbury in 1759 as the British Museum. In 1939 the Museum advised the purse was still in the Mineral collection and was a small, closely plaited bag in a fairly good state of preservation, with a thread running through the top. Since the bag was "plaited" it can be said it was the first known asbestos textile made in America.

Δ Blue asbestos was discovered near the Orange River, South Africa, in 1816. The name "Crocidolite" meaning "flakey" or "woolly" stone, was applied to it in 1831. Commercial exploitation of the fiber began in 1893.

Δ Amosite was first known in 1907 in Central Transvaal. The name was given to it in 1918, being taken from the initials of the company most interested in its production–Asbestos Mines of South Africa. Commercial production started in 1916.

Δ Rhodesia first reported production of asbestos in 1908 (55 tons of Chrysotile).

Δ Asbestos in itself does not have low heat conductivity. Its extensive use for heat insulation is due to its fireproof qualities. The porous structure or aircell content of asbestos-based insulation materials accounts for their insulation value.

Δ Italy is called the "Cradle of the Asbestos Industry" because the mining of asbestos and the manufacture of asbestos products began on an industrial scale in that country.

Δ Asbestos was found in the Ural District of the USSR between 1710 and 1720.

Δ Asbestos was discovered in Vermont in 1824 but the first production was not recorded until 1908.

Δ A patent on steam engine packing using asbestos was granted as early as 1857 to Richard Lloyd, of England.

Δ Insulation containing asbestos was first used in 1866. It was made of asbestos fiber and silicate of soda and was in sectional form.

Δ Great Britain's asbestos manufacturing industry began in 1871 in a factory founded by Patent Asbestos Manufacture Limited, Glasgow, Scotland.

Δ The first known attempt to make asbestos paper was in 1765. It was first made in the United States around 1878.

Δ The Cape Asbestos Company Limited was the original spinner of Crocidolite asbestos–as early as 1895.

Δ Ludwig Hatschek, an Austrian, invented asbestos-cement shingles in 1900. In 1905 they were introduced into the United States by the Keasbey & Mattison Company, Ambler, Pennsylvania. The basic Hatschek process was later adapted to the manufacture of asbestos-cement pipe.

Δ The first compressed asbestos sheet (Klingerit) was produced in 1895 by Richard Klinger, the founder of the Klinger Group of Companies, England. This made possible modern high-pressure steam engineering.

Δ Asbestos-cement pipe was first used for carrying corrosive salt water for street cleaning and fire fighting in an Italian seacoast town.

Δ Patents on asbestos-cement pipe were granted in Italy in 1913 and manufacture begun in 1915 by Eternit Pietra Artificiale in Genoa. The product was introduced into the United States by Johns-Manville Corporation in 1929 and the first shipment by J-M was made in 1930.

Δ Amosite asbestos was first spun in England in 1924 by The Cape Asbestos Company Limited. The pioneer in the spinning of Amosite was S. Weingarten, of South Africa, who spun Amosite yarns as early as 1909.

Δ Asbestos was first used in automotive brake lining in 1906.

Δ The United States is the largest consumer of asbestos in the world.

ASBESTOS IS FOUND ....

The four largest asbestos-producing countries are Canada, the USSR, the Republic of South Africa and Southern Rhodesia.

Despite the fact that asbestos is found in practically every country in the world, its occurrence in "satisfactory quality and economic quantity" is not common. Although deposits are continually being reported, there are very few which, upon examination, are found to warrant the expense necessary for development. The following tabulation forms an index to the varieties of asbestos produced in the various countries or localities.

AFRICA

Chrysotile of excellent quality and low-iron content is produced in Southern Rhodesia and Swaziland. The majority of the Rhodesian producers are located near Shabani, Mashaba and Filibusi. The Ethel Mine, near Salisbury, operated for 15 years but was closed in 1966.

Amosite, Chrysotile and Transvaal Blue are extensively produced in the Transvaal. Small amounts of Tremolite are also produced from time to time. Cape Province produces the well-known Cape Blue exclusively and extensively. Actinolite is also produced in Cape Province. Asbestos is produced in Mozambique (Tremolite), Botswana (Chrysotile) and Kenya (Anthophyllite). An Anthophyllite asbestos deposit was recently discovered in the Northern Transvaal and the property is being studied for its economic potential. Although there are asbestos occurrences in Natal, no fiber is currently being produced.

Production of four varieties of asbestos (Amosite, Chrysotile, Cape Blue and Transvaal Blue) totaled 284,587 short tons in 1969.

AUSTRIA

In past years, short-fibered Amphibole known as "Micro-Asbestos" had been produced and was used for road surfacing in combination with concrete or asphalt. However, no production has been reported since 1963 (600 tons produced; 16 tons exported).

AUSTRALIA

Chrysotile and Crocidolite of various qualities and lengths are found in Australia. Chrysotile deposits are presently being explored and developed. Production of asbestos in 1969 totaled 822 short tons.

CANADA

The Chrysotile variety is found principally in the Provinces of Quebec, Ontario, British Columbia, Newfoundland and the Yukon Territory. The asbestos mines in Quebec are the best known in the world. Canadian quality and grading are considered as "standard" the world over. Producers' shipments in 1969 totaled 1,576,876 short tons.

CHINA (MAINLAND)

The most active Chrysotile deposit is located at Shihmien (which means "asbestos"), in Szechuan Province. Chrysotile is also produced in Chihli (Hopeh) Province and Manchuria. In 1968, possibly 150,000 metric tons of asbestos were produced in China, most of which was consumed domestically. Mainland China provided a possible 4% of the world production total.

CYPRUS

Good quality Chrysotile is produced, mostly of the "shingle stock" grade or lower. In 1969, asbestos production totaled 21,363 short tons.

FINLAND

Produces fair quantities of short Anthophyllite.

GREECE

The Zidani Asbestos Mine, near Kozani, Greece, is currently undergoing further exploration to verify the feasibility of putting the property into commercial production.

INDIA

Produces both Amphibole and Chrysotile to some extent. Preliminary statistics on asbestos in 1968 showed a production total of 9,065 metric tons.

ITALY

Chrysotile of fair grade and Tremolite of excellent quality are produced. During recent years there has been a substantial increase in the production of asbestos. In 1968, output rose 2.6% to 103,437 metric tons.

JAPAN

22,000 metric tons were produced in 1968, mostly of the Chrysotile variety.

MEXICO

The Novillo Arroyo area, near Ciudad Victoria, Tamaulipas, has long been known to contain a potentially-productive asbestos property. A new company has recently been formed to mine and process Chrysotile asbestos in the area. Late in 1969 it was reported that an exploration program was being carried out in Southern Mexico.

PAKISTAN

Produces fair amounts of Tremolite.

SOUTH AMERICA

A small amount of asbestos is produced in Argentina and in the States of Bahia and Goias, Brazil. Brazil produced 4,360 metric tons of asbestos in 1968. Other deposits are reported in Chile and Venezuela. Long Blue asbestos, too brittle for spinning, is found in Bolivia and very small amounts are being produced (4 tons in 1968). An asbestos-bearing property was recently discovered in the Department of Antioquia, Colombia, and a mine will soon be developed.

TURKEY

Produces small amounts of asbestos (3,183 metric tons in 1968). Presently conducting drilling projects near Sivrihisar and on the Karaburum Peninsula.

USSR

Chrysotile asbestos development is centered in the Ural Mountains, in Kazakhstan and in the Tuva ASSR. Anthophyllite and other varieties have been mined at the small Sysertsk deposit and in other areas. In 1968, the USSR produced an estimated 800,000 metric tons of six grades of asbestos. According to Soviet sources, a new Chrysotile asbestos deposit was discovered in 1968 in Bauntov County, Buryat ASSR. At present most of the asbestos produced in the USSR is consumed internally.

UNITED STATES

Alaska has reported deposits of Amphibole in the past. A new occurrence of Chrysotile was discovered in 1968 in the Eagle C-4 Quadrangle, adjacent to the Yukon Territory of Canada.

Arizona mines produce an excellent long-fiber Chrysotile, valuable for electrical insulations because of its iron-free nature. The shorter fibers are also very well suited for filtration purposes. Tremolite asbestos has been reported. Asbestos has been mined from about 160 deposits and perhaps another 60-70 occurrences have been explored.

California has extensive deposits of short Chrysotile fibers presently being worked. The State is the largest producer, tonnage-wise, of the four asbestos-producing States in the United States (75,592 short tons in 1968, valued at $6,139,000). Tremolite asbestos has been produced in commercial quantities for Gooch Crucible use.

Georgia has been a producer of Anthophyllite asbestos although no production has been reported of late.

Maryland has, in the past, produced Anthophyllite and Tremolite fibers suitable for filtering purposes, but no significant production has been reported recently.

North Carolina has attained some importance as a producer of Anthophyllite asbestos. Asbestos is presently being produced, by the open-pit method, near Burnsville, Yancey County.

Vermont produces good grades of Chrysotile ranging from shingle stocks to shorts. The deposits are located on Belvidere Mountain in Orleans County and are actually an extension of the veins from Thetford Mines, Quebec, Canada.

Although not exploited on a commercial scale, small asbestos occurrences have been reported in Connecticut, Idaho, Maine, Michigan, Montana, New York, Oregon, Pennsylvania, South Carolina, South Dakota, Texas, Virginia, Wisconsin and Wyoming.

Total U.S. production of Anthophyllite and Chrysotile asbestos in 1969 was approximately 127,000 short tons, valued at an estimated $10,500,000. In 1968, sales of U.S.-produced asbestos totaled 120,690 tons, valued at $10,406,000.

YUGOSLAVIA

Produces a small amount of asbestos (10,393 metric tons in 1968). Two mines are presently under modernization and expansion.

PRODUCTION IN OTHER COUNTRIES

Small to fair amounts of production have been reported in Bulgaria, Czechoslovakia, Eritrea, Ethiopia, Formosa, France, Indonesia, Malagasy, North Korea, the Philippines, Portugal, Rumania, South Korea, Taiwan and the United Arab Republic.

OCCURRENCES IN OTHER COUNTRIES

Occurrences of asbestos of various types have been reported from time to time in Afghanistan, Albania, Algeria, Corsica, Cuba, Germany, Ireland, New Zealand, Spain, Switzerland, Spitzbergen (Norway), Syria and Morocco.

THE USES OF ASBESTOS & ASBESTOS PRODUCTS

This list of uses of asbestos and asbestos products includes only the basic and more important uses – those which consume the largest volume of asbestos (or the product made therefrom) or those in which the amount of asbestos used may be small but whose functions can be adequately performed only because of the unique properties of the asbestos used in their manufacture.

No attempt has been made to list *every* end use of *every* asbestos product. For example, asbestos-cement sheets may be used in hundreds of different *types* of buildings. It would serve no purpose to list all these different building *types*. The list, therefore, is confined to the various parts of buildings of any type in which such sheets can be, or have been, used.

In the interest of clarity the "Uses of Raw Asbestos" have been separated into categories depending chiefly on the prime *function* performed by the fiber in each case. The list is confined to uses and products directly incorporating raw fiber. *Example:* Raw asbestos fiber is carded and processed into Roving. All spun and woven textile products are made by further processing roving into wick, rope, yarn, cloth, etc. Since the roving is the basic *textile* material made directly from raw fiber, it is the only one listed. [Currently, much effort is being expended to produce asbestos yarn directly from a suspension of asbestos fibers in a liquid. However, until such processes are perfected, the spinning of yarn from roving will continue to be the almost universally used process.] Uses of the products made from roving are listed under their own names such as Yarn, Cloth, etc.

There are innumerable uses of asbestos and its products which are novel and interesting but are unimportant from the viewpoints mentioned. Many of these uses have been published in ASBESTOS but they are not included in the following list for the reasons noted.

USES OF RAW ASBESTOS

- Rovings from which all spun & woven textile products are made
- Felts (non-woven)
- Paper, Millboard & Rollboard
- Reinforcement in:
  - Asbestos-cement products (with Portland cement) –
    - flat & corrugated sheets, shingles, pressure pipe, sewer pipe, rectangular air & fume ducts, industrial roof ventilators, cooling tower packing, extrusions (such as special shapes for building products), etc.
- Asphalt & vinyl floor tiles
- In latex backing paper for vinyl roll goods flooring

Compressed sheet packings
Molded thermal insulations
Molded plastic products
Plaster, stucco & cement grouting material
Exothermic & refractory tiles used in the steel industry
Space vehicle heat shields
Asphalt paving and overlay mixes
Marine fences (asbestos-rubber sheets)
Thermal Insulation:
mattress type (for turbines, etc.), molded fiber (with binders), sprayed (with binders), loose fill for conduits, etc., pipe & boiler cement.
Electrical Insulation (extruded with binders on wires & cables)
Acoustical Insulation (fire-resistant):
sprayed (with binders), tiles, panels, felts.
Friction Materials:
Molded brake linings, brake blocks & clutch facings.
Fillers (very short fibers):
molded plastics, mastics, sealants, paints & varnishes, glass fiber products.
Protective Coatings:
Intumescent (fire-resistant paints),
Fireproofing (sprayed with binder on structural steel),
Anti-condensation (sprayed with binder on various base metals),
Auto body undercoating (sprayed with binder),
Pipeline (sprayed with binder).
Filtration medium for beer, wines, plasma, sugar, industrial water, acid & alkaline chemicals, and for entrapment of air-borne radioactive particles.
Wadding in cartridges & priming devices
Welding rod coatings

USES OF ASBESTOS YARN

Cloth
Tape (electrical & other)
Brake lining (combination of yarn & folded & stitched cloth)
Clutch facings (woven)
Packing (valve stem, braided & other)
Tubing
Wick for oil-burning apparatus
Rope, twine & sewing thread
Stockings for lead cables
Electrical insulation for wires & cables (lap, roving, yarn, tape)
Tying gas mantles
Gaskets for spark plugs
Edges for hair felting
Steam hose
Fire-retardant hose

USES OF ASBESTOS TAPE

Wick for oil-burning apparatus
Belts for conveying glass or other materials in hot processes
Insulating steam pipes at bends (Lagging)
Electrical insulation (heat-resistant) for:
wires & cables of all types, motor armatures & field coils, bus bars, appliance cords (irons, toasters, dryers, unit heaters).

Laboratory uses such as insulation for flasks, test tubes, retorts & tie straps in diffusing materials
In glass manufacture for wrapping tines of forks used to remove bottles from ovens

USES OF ASBESTOS WICK & ROPE

Packing, chiefly for low pressures & miscellaneous repair work
Wiping of wire & sheets after hot-dip galvanizing

USES OF ASBESTOS CLOTH

Packing (sheet, high pressure, folded or wound)
Brake lining (folded & stitched)
Clutch facings
Gaskets
Heat insulating mattresses
Substitute for canvas covering on insulation where temperatures are high
Clothing (suits, helmets, gloves & mitts, aprons, etc.)
Draperies
Hangings for firestops
Blankets for fire fighting
Blankets for electrolytic cells
Bags & diaphragms (in oxygen producing)
Mail bags
Awnings
Rugs
Theater curtains & floor lining
Motion picture screens
Acoustical treatment
In acetylene welding
Facing for dryer felts
Filtering (fruit juices, acids, etc.)
Filter in dust collectors (particularly of zinc oxide)
Oven insulation
Lining in electric motors
Lining of laboratories, cooling chambers & other rooms
Asbestos wipers in the tin-plating of steel sheets
Ironing board covers
Covers for flat-work ironer rolls
Covers for laundry & dry-cleaning presses
Padding for flat-work ironer rolls (or mangles) & in laundry presses
Padding prison cells
Wrapping oil tanks & oil lines in engines
Umbrellas & shields (to protect firemen)
Sand bags for pressing hats
Conveyor belting
In hay-curing to preserve aroma & color
In cheese-making to control temperature
Insulation against noise & vibration in aircraft, spacecraft & buildings
Reinforcement for plastic laminates

USES OF ASBESTOS FELT

Flexible, non-woven, thermal insulation
In acoustical insulation materials
Protection of underground pipe
On paper machines (dryer felts)
Asphalt-asbestos roofing felts

USES OF ASBESTOS PAPER

Air cell & other pipe coverings
Boiler jackets
Asbestos felt roofing
Asbestos built-up roofing
Asbestos-protected metal roofing
Gaskets (plain & metal reinforced)
Wick in oil-burning apparatus
Tubes for electrical insulation
Electrical insulation of wire & cable
Insulation of hot-air pipes
Linings of stoves & heaters
Linings of filing cabinets, cartridges, carpets, auto mufflers, drum controllers, cookers, electrical appliances, armored car roofs, motors, etc.
In enameling ovens to catch drip
Insulation of ovens & dry kilns
Table pads & mats
Heat- and chemical-resistant reinforced plastic pipe & other laminated products
Diaphragms in electrolytic cells
Tank covers
Reinforcing aluminum foil for insulation
Filtering
In window-glass machinery to guide hot sheets & to shield hot glass from flying fragments
In welding & other processes for protection from heat
In annealing (crumbled paper)
In chemical & physics laboratories
Insulating exhausts on automobiles
Clutch facings in automatic transmissions
Baking sheets
Hot-air ducts or lining of paper ducts for hot-air service

USES OF ASBESTOS MILLBOARD

Linings of safes, stoves, heaters, garages, electric switch boxes, dry-cleaning machines, incinerators, and bottoms of brooder stoves, ovens and dry kilns
Fireproof wallboard
Ceiling over boilers, smoke stacks, etc., for fire protection
Gaskets (plain & metal reinforced)
Paddles in glass mills
Washers in electrical apparatus

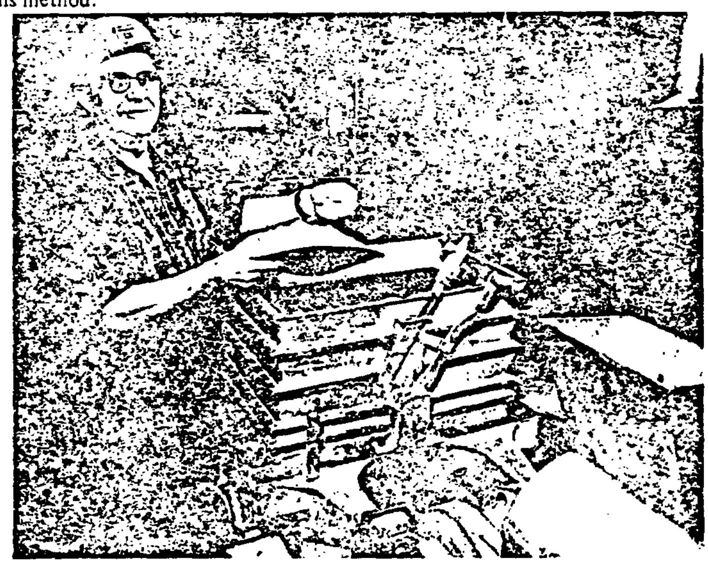
THE QUEBEC STANDARD ASBESTOS TESTING MACHINE

The Quebec Standard Asbestos Testing Machine consists of a nest of four boxes measuring 14-3/4" x 24-1/2" superimposed one on another and resting on a table which is given a combined horizontal and vertical reciprocating motion by an eccentric driven by an electric motor. The bottoms of Boxes No. 1, 2 and 3 are made of brass wire screen to the following specifications:

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

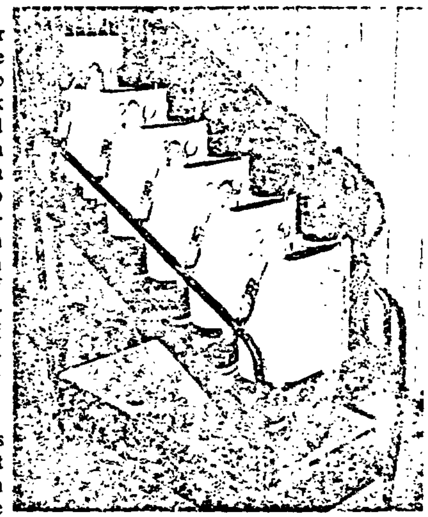
The bottom of Box No. 4 is of solid sheet metal and serves as a receptacle for the fines which fall through the three preceding screens. This is known as the "pan."

The test consists of obtaining a 16-ounce sample of fiber from each lot to be tested. Sampling is done in accordance with rules established by the Quebec Asbestos Mining Association to assure a sample truly representative of the lot. The 16-ounce sample is placed in the upper (No. 1) Box which is then tightly covered. The machine is then started and run until exactly 600 revolutions of the drive shaft have been made. At the end of this time the weight of material remaining on each screen and in the pan is determined. The longer fibers remain on the No. 1, 2 and 3 screens while the No. 4 pan collects the very short fibers or "waste." It is evident that the figures obtained by the test represent the number of ounces of each length of fiber retained by each screen in the machine and these figures are an acceptable measure of the Grade of the fiber being tested. Most of the world's production of Chrysotile asbestos is graded for purchase and sale by this method.



BAUER-McNETT WET CLASSIFICATION TEST FOR ASBESTOS FIBER

A very accurate determination of the length distribution and fines content of milled asbestos fiber can be made by wet classification using the Bauer-McNett Fiber Classifier in accordance with standardized methods set forth in "Testing Procedures for Chrysotile Asbestos Fibre, (Second Edition, 1966)" and in "ASTM Method D2589 for Bauer-McNett Classification of Asbestos Fiber."



The classifier consists of four tanks (later models incorporate five tanks) arranged in cascade so the effluent from the first tank flows by gravity into the second and so on until the overflow from the last tank discharges into a drain. Each tank is divided into two unequal sections by a removable screen. The larger section of each tank is provided with means for mechanical agitation of the water-asbestos dispersion passing through and, at the bottom of each tank, is a drain hole, pipe-connected to a filter-holding drain cup.

In operation, each tank is fitted with a screen of different mesh, the coarsest mesh being in the first tank and the finest in the last tank. A weighed filter paper is positioned in each drain cup. Drain holes are stoppered, the tanks are filled with water, the agitators are started and the flow of water into the larger section of the first tank is adjusted to obtain a steady flow from tank to tank and from the last tank to the drain. A weighed sample of the fiber to be tested – usually 10 grams – is dispersed in water and poured into the larger section of the first tank. Water flow and agitation are continued for either 20 or 30 minutes, depending on the sample being tested, and then shut off. At the end of the run, each tank is drained through its own filter cup and the screen and tank interior are thoroughly rinsed, insuring that all fiber adhering to them is deposited on the filter paper for that tank. The filter papers with their individual sample fractions are removed, dried and weighed. By calculation, the percentage of the original sample remaining in each tank and the percentage passing through the last tank is determined.

The mesh of the screens used and the percentage of the sample retained in each tank serves as a precise measure of the Grade of fiber under test.

ASBESTOS GRADES IN CANADA

Source: Quebec Asbestos Mining Association

CANADIAN CHRYSOTILE ASBESTOS CLASSIFICATION

The *"List of Standard Grades"* was set up by the Committee on Uniform Classification and Grading of Asbestos Mines Products. This Committee was formed in 1931 at the instigation of the Minister of Mines of the Province of Quebec. The list of Grades has been revised from time to time – the latest revision being January, 1964.

The asbestos mines products are divided into two classes, i.e.: *"Crude Asbestos"* which consists of the hand-selected, cross-vein material essentially in its native or unfiberized form; and *"Milled Asbestos"* which consists of all Grades produced by mechanical treatment of asbestos ore.

The "Crude Asbestos" and the "Milled Asbestos" are subdivided into Groups (designated and defined on the opposite page). Classification of the "Milled Asbestos" Grades, in Groups 3 to 7, inclusive (unless otherwise specified), is based on tests run on the *"Quebec Standard Asbestos Testing Machine."* (See page 22 for a description of this machine.)

The *"Shipping Test"* is the average, for each carload or smaller shipment, of tests of representative samples.

The *"Guaranteed Minimum Shipping Test"* is that below which the actual shipping test shall not fall.

Group No. 1, Crude No. 1	– consists basically of crude 3/4" staple and longer.
Group No. 2, Crude No. 2	– consists basically of crude 3/8" staple up to 3/4".
Group No. 2, Crude run-of-mine	– consists basically of unsorted crudes.
Group No. 2, Crudes sundry	– consists of crudes other than above specified.
Groups No. 3 through No. 9	– are "Milled Asbestos."

STANDARD GRADE DESIGNATION		GUARANTEED MINIMUM SHIPPING TEST			
Group No. 3:	3F	10.5	3.9	1.3	0.3
	3K	7.0	7.0	1.5	0.5
	3R	4.0	7.0	4.0	1.0
	3T	2.0	8.0	4.0	2.0
	3Z	1.0	9.0	4.0	2.0
Group No. 4:	4A	0.0	8.0	6.0	2.0
	4D	0.0	7.0	6.0	3.0
	4H	0.0	5.0	8.0	3.0
	4J	0.0	5.0	7.0	4.0
	4K	0.0	4.0	9.0	3.0
	4M	0.0	4.0	8.0	4.0
	4R	0.0	3.0	9.0	4.0
	4T	0.0	2.0	10.0	4.0
	4Z	0.0	1.5	9.5	5.0
Group No. 5:	5D	0.0	0.5	10.5	5.0
	5K	0.0	0.0	12.0	4.0
	5M	0.0	0.0	11.0	5.0
	5R	0.0	0.0	10.0	6.0
	5Z	0.0	0.0	8.6	7.4
Group No. 6:	6D	0.0	0.0	7.0	9.0
Group No. 7:	7D	0.0	0.0	5.0	11.0
	7F	0.0	0.0	4.0	12.0
	7H	0.0	0.0	3.0	13.0
	7K	0.0	0.0	2.0	14.0
	7M	0.0	0.0	1.0	15.0
	7R	0.0	0.0	0.0	16.0
	7T	0.0	0.0	0.0	16.0
	7W	0.0	0.0	0.0	16.0
Group No. 8:	8S	under 50 lbs/cubic foot loose measure			
	8T	under 75 lbs/cubic foot loose measure			
Group No. 9:	9T	over 75 lbs/cubic foot loose measure			

ASBESTOS GRADES IN ARIZONA

Source: Metate Asbestos Corporation, Globe, Arizona

The same "Guaranteed Minimum Shipping Tests" are used in Arizona as are used in Canada, with the following exceptions:

3Z (Soft Filter Grade) is held to –	0 10 4 2
Special Sugar Grade LX-222-NAW is held to about Canadian Grade 3T -	2 8 4 2

All other Arizona Grades follow Canadian grading procedures but add the following designations:

S	– Soft
H	– Harsh
AW	– Acid Washed
NAW	– Non-Acid Washed

ASBESTOS GRADES IN CALIFORNIA

Source: Coalinga Asbestos Company, Inc., Coalinga, California

The following short Chrysotile asbestos fiber grades are available from Johns-Manville Corporation's Coalinga Mine at Coalinga, California. While the chemical composition of Californian fibers is very similar to that of Canadian Chrysotile, they are typically lighter in color, lower in fines content and higher in surface area.

ULTRABESTOS Red Brand: a high surface area, high absorption, low fines general-purpose short fiber.

ULTRABESTOS Blue Brand: a high quality, low fines short fiber somewhat similar to Canadian Grade 7R. This Grade is prepared especially for use in vinyl floor tile.

Coalinga Floats: an extremely short fiber having a minus 200 mesh content of approximately 95% by the McNett test. (See page 23 for a description of this test.)

Coalinga Paperbestos-100: an extremely short fiber prepared for use in the papermaking industry as a pitch control and pigment retention aid.

Coalinga Asbaltic: a medium absorption short fiber for asphalt paving applications.

ASBESTOS GRADES IN SOUTH AFRICA

Data on Blue (Crocidolite) and Amosite (Silver Grey) Grades were submitted by The Cape Asbestos Company Limited, London, England.

Data on Gefco Cape Blue and Chrysotile were submitted by General Mining and Finance Corporation Limited, Johannesburg, South Africa.

BLUE (CROCIDOLITE)

Grade	Average Fiber Length
WDS	2 mm.
H	4 mm.
2S	10 mm.
S	12 mm.
A	18 mm.
C	35 mm.

AMOSITE (SILVER GREY)

Long	D11, M, M/65, W3, K3	18 mm. and over
Medium	S22, S22/65, SW, SK	12 mm.
Short	S33, S33/65, GW, GK, S44	6 mm.

GEFCO CAPE BLUE (GRIQUALAND BLUE) CROCIDOLITE

Each Grade is produced in varying degrees of openness. The listings in the table below represent typical crudy fibers in each Grade.

Grade	Bauer-McNett Testing Procedure*				
	+4	+14	+35	[illegible]	[illegible]
L	55	13	5	[illegible]	[illegible]
ML	43	17	[illegible]	[illegible]	[illegible]
M	30	23	11	[illegible]	[illegible]
MS	24	24	12	4	[illegible]

*See page 23 for a description of the Bauer-McNett [illegible]

CHRYSOTILE (PRODUCED AT MSAULI [illegible])

Graded by the Quebec Standard Asbestos Testing [illegible]

Grade	Guaranteed [illegible]			
ACA 4R	0.0	3.0	[illegible]	[illegible]
ACA 5K	0.0	0.0	[illegible]	[illegible]
ACA 5M	0.0	0.0	[illegible]	[illegible]
ACA 5R	0.0	0.0	[illegible]	[illegible]
ACA 6D	0.0	0.0	[illegible]	[illegible]
ACA 7	0.0	0.0	[illegible]	[illegible]