Asbestos

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Third Year Applied Science

Geological Engineering

Chrysotile Asbestos in Canada

2856 West 44th Avenue,
Vancouver, B. C.,
November 13th, 1953.

Dr. H. C. Gunning,
Dean of the Faculty of Applied Science,
University of British Columbia.

Dear Sir:

I would like to submit my term essay entitled "Asbestos", written in accordance with the specifications listed in the 1953-54 calendar for Third Year Applied Science.

During the summer of 1952 I noticed numerous veins of slip fiber asbestos occurring in the serpentinized rocks of the Pacific Nickel property. Last summer while with the Geological Survey of Canada, I again noted vein fiber in a large serpentine body located in the Wolf Lake area of the Yukon Territory. Although the latter deposit is of no economic value, there is an important deposit of chrysotile asbestos several miles to the south in the Cassiar district, B. C. These occurrences, and the odd properties of the mineral, seemed to me to be of interest. For these reasons I chose to base my essay upon asbestos.

Yours truly,

W. G. Smitheringale

W. G. Smitheringale.

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Pres. 35 27
Eng. 40
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A S B E S T O S

An Essay submitted during the third year

of the Course in Applied Science at the

University of British Columbia

WILLIAM GEORGE SMITHERINGALE

November 13, 1953

C O N T E N T S.

I L L U S T R A T I O N S

P R E F A C E

This essay is based mainly on material collected by reading. The reference for most of the milling methods described was <u>Chrysotile Asbestos in Canada</u> by J.G. Ross. The physical properties and commercial uses of asbestos were also obtained from reference books. Material from these references was modified by personal knowledge of more recent developements.

W. G. Smitheringale

Nov. 13, 1953

A S B E S T O S

PURPOSE AND SCOPE OF THIS ESSAY

This essay is intended to serve as a general review of the Canadian asbestos industry. The history of the industry in Canada and some of the more interesting properties of the asbestos minerals are described briefly. An attempt has been made to emphasize the industrial importance of asbestos; a fact which I believe few people realize. Special attention is given to the milling of the fibre, and pictures, illustrating some of the equipment used, are included.

INTRODUCTION

Asbestos is one of the major industrial minerals of today. Previous to 1800 it was regarded by museums and scientific societies as an oddity and its uses in cloths and wicks were very limited. However, during the early part of the nineteenth century more practical uses were found for this amazing mineral, and about 1880 the first mining of Canadian asbestos was undertaken. The Canadian asbestos industry remained small until the middle 1930's, when the full value of asbestos as an industrial mineral began to be appreciated. At present Canada is the major producer, supplying approximately ninety percent of the asbestos used in North America. In 1952 Canadian production was estimated at 966,380 tons valued at approximately 88.8 million dollars.[1]

Chemically the asbestos minerals are hydrous magnesium calcium silicates, containing varying amounts of iron. Commercial varieties are crystalline and fibrous. Ability to withstand heat, exceptional tensile strength, fineness and flexibility are the most outstanding properties of the fibre.

There are six commercial asbestos minerals, chrysotile; amosite; crocidolite; anthophyllite; actinolite; and tremolite. Chrysotile, amosite and crocidolite are preferred by the asbestos industry due to the superior properties of their fibres.

Asbestos is associated with serpentine bearing rocks and occurs

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1. "Production Statistics", Asbestos, Philadelphia, January, 1953, p.28

in small veinlets, in which the fibrous crystals are generally oriented perpendicular to the walls. The average length of fibre is considerably less than one-half inch, but fibre lengths of one to two inches may be found in small quantities in any deposit. Fibres up to three inches are rare, although some five inches in length have been found. The bulk of Canadian asbestos is mined in the Thetford area of Quebec. The post war development of the asbestos occurrences in the Matheson area of Ontario, has resulted in an appreciable production of shorter length fibres, while the recently developed occurrence at Cassiar, in northern British Columbia, holds promise of supplying important amounts of high grade spinning fibres to the asbestos industry.

A typical outcrop of asbestos bearing serpentine is shown in Figure 1:

Fig. 1. Asbestos Veins in Serpentine, Cassiar, B.C.

DESCRIPTION OF ASBESTOS MINERALS.

Chrysotile

Chrysotile is the most useful of the asbestos group of minerals due to its superior quality and comprises about 90% of all fibre used. Its flexibility, fineness, tensile strength and softness make it the most desirable of mineral fibres for spinning into yarn and fabrics. It is the lightest of the asbestos minerals (S.G.2.4. to 2.6) and is second ~~only~~ in tensile strength only to crocidolite. An industrial drawback is its solubility (up to 57%) in hydrochloric, phosphoric, acetic and sulphuric acids.

Nearly all the chrysotile fibre used in North America is produced in Canada. The Canadian chrysotile is preferred by the manufacturers because of its longer fibres and superior spinning characteristics.

Amosite

The chief source of amosite is Africa. Amosite fibres have less tensile strength than chrysotile and their spinning qualities are only fair. It is bulky and has good heat resisting properties. When mixed with chrysotile fibre and special cements, it produces an excellent light weight, strong, fire resistant wall board.

Crocidolite

Crocidolite asbestos is found in commercial quantities in South Africa and Australia. It's two outstanding properties are very high tensile strength (see Table 1 appendix) and resistance to acids. When formed into a mat it has very good filtering properties. However, its flexibility is less than chrysotile and amosite and accordingly is less adaptable to spinning techniques.

Anthophyllite, Actinolite, Tremolite.

Anthophyllite, Actinolite and Tremolite fibres are all harsh, brittle and low in tensile strength and accordingly are not adaptable to the spinning trade. The production of these minerals is limited due to their specialized use in industry as filters for fruit juices and some acids, special types of cement and some roofings. wrong use

The more important physical properties of the asbestos fibres are tabulated in Table 1, Appendix 1. It should be noted that the three prominent fibres, chrysotile, amosite and crocidolite all exhibit good properties of flexibility, length, texture, tensile strength and spinnability. As a point of interest, Table 2, Appendix 1, is given to show the comparative tensile strengths of asbestos fibres and other common materials.

MINING METHODS.

Previous to 1935 practically all asbestos in Canada was mined from open pits. As long as these workings remained relatively shallow, in comparison to their width, this was the most economical method. As the pits increased in depth, more and more time was lost due to slides from the side walls, which necessitated major scaling operations along the sides to protect men and equipment from the rock falls. To overcome these expensive secondary operations some companies began to extract the asbestos ore from underground workings and found this an efficient wrong use method of operation. The serpentine rock, containing the asbestos, is an incompetent rock in which it is extremely difficult, if not impossible, to maintain large underground openings necessary for cheap mining costs. This was overcome by using the block caving system, whereby large blocks of ore, - as much as 200 ft. to the side - are undercut and allowed to cave. The broken ore is withdrawn mechanically from the caved section into main haulage levels about the perimeter of the caved block and then hoisted through main shafts to the surface. This method not only overcame the danger of working in the open, under unstable rock walls, but also eliminated much lost time in the open pits during the winter months due to snow and ice. However, it became apparent, in those mines with an appreciable amount of long fibre, that the recovery of this premium grade asbestos decreased sharply because the attrition to which the fibre was subjected during the caving of the block and subsequent removal of the ore destroyed much of the longer fibre. As this became evident, the companies improved their open pit techniques, in order to maintain the maximum possible production of spinning grade fibres. With the advent of modern truck haulage, one method, where feasible, was to cut inclined spiral roadways along the sides of the pits to the various levels or benches in the pit working. These roadways served to remove much of the dangerous slide material from the sides and also allowed the use of a flexible and cheap transport system from the pit to the mill. Today both open pit and underground mining methods are in use. Figure 11 illustrates a large open pit at Bell Asbestos Co. operations, Thetford Mines, Quebec.

Fig. 11. Open pit mine. Thetford Mines, Que.

Figure 111 shows asbestos veins in the face of the main exploratory crosscut working at Cassiar Asbestos Corporation mine, northern British Columbia.

Fig. 111 Underground face showing asbestos veins in serpentine.

THE DRESSING OF ASBESTOS FOR MARKETING

The ultimate objective of asbestos dressing is to recover from the broken asbestos bearing rock the maximum yield of fibre, both in quality and quantity, in the cheapest manner possible. The particular method and sequence of operations chosen by a company to obtain this objective necessarily depends upon the type of ore to be treated and the grades of fibre to be produced. Theoretically, each mine should have a mill specifically designed to treat the ore available. Hardness of the rock in which the asbestos is found and the average length of fibre mined, are two important factors which vary from mine to mine. In the early days of the Canadian asbestos industry, this approach was not realized and some mills were inefficient because of conformation to a standard mill plan.

Recovery of fibre from the ore may be divided into two general operations: hand dressing and mill treatment.

Hand Dressing:

Hand dressing refers to the preparation of "crude" fibre. The term "crude" is applied to all fibre over 3/8" long. There are two grades of crude fibre:

No. 1 crude which is made up of fibres 3/4" in length or longer.

No. 2 crude which is made up of fibre from 3/8" to 3/4" in length. These grades are obtained by hand picking this type of material from the broken rock, both in the open pit, and later from the conveyor belt which carries the broken rock from the primary crusher. After this hand sorting , the crude ore is dried on steam tables, the larger pieces of rock broken free by hand cobbing, and then the fibre veins are hammered to partially open the fibres, and remove the small fragments of rock adhering to the end of the veins. After this treatment the material is screened, to remove the sand from the fibres, and bagged.

The October[4] 1953 price per ton, f.o.b. mine, of Canadian crude, was quoted as:

No. 1 crude $1100.00 to $1500.00

No. 2 crude $ 500.00 to $1000.00

These prices emphasize the advantage of careful picking of crude material prior to the ore entering the fiberizing circuit of the mill, since there is no satisfactory way of separating the long crude fibres from the shorter grades, after the fiberizing, or full opening of the fibre has started.

Shouldn't hand-dressing and milling etc have headings of equal emphasis or rank?

MILLING OF ASBESTOS BEARING ROCK.

The milling of asbestos bearing rock is a dry process and consists essentially of breaking the rock in successive stages and the removal of the opened fibres by suction after each breaking stage in order to obtain the fibres in the maximum possible length and with the minimum damage done to the fibre. Because the price obtained for the product is directly dependent upon the length of fibre, care should be taken to remove the fibre as soon as it has been released from the rock, otherwise it may be damaged. Sand and small rock particles are

certain amount of repetition in this paragraph

(4) - "Asbestos", Philadelphia, Oct. 1953

screened out and the opened or fluffed fibre is drawn off after each crushing by suction fans.

Primary Crushing

The ore, from either the open pit or underground working, is fed to a standard primary jaw crusher with opening set from 4" to 6" discharge. The ore is dumped into a chute and passes over a grizzly prior to entering the jaw crusher. The grizzly allows the undersize (minus 4") to by-pass the crusher. This serves a dual purpose. It frees the crusher from the cushioning effect of the fines, and thus increases the efficiency of the primary crusher, and secondly, any free fibre is protected from damage.

Undersized ore from the grizzly mixes with the broken ore from the crusher, in a storage bin, from which it is withdrawn and carried by conveyor belts to the drying kilns. The bin is of sufficient capacity to furnish sufficient reserve to maintain a steady feed to the drying units. The conveyor belts may be used as picking belts for crude ore, and are sometimes in two sections which assists in the picking by turning over the ore stream in the drop from one section to the next. Scrap wood and iron are also removed during the picking, although magnetic pulleys at the ends of the belts are usually relied upon to remove any stray iron from broken drill rods, bits, hammer heads, etc.

Drying

Drying of the ore may be done either in a rotating dryer or in a stack dryer.

The rotary dryer consists of a long, cylindrical steel shell, reinforced and protected inside with removable liners. Circular, external tracks, on which the dryer, or kiln, rotates slowly also lend reinforcing to the shell. The kiln is usually inclined slightly, about 7°, towards the discharge end. The size may vary from 40 ft. to 60 ft. in length and 4 ft. to 6 ft. in diameter. Longitudinal bars, or ribs, within the kiln, lift the ore and allow it to fall through a stream of hot air which is drawn through the kiln. The capacity of a kiln depends on its size, the largest being able to dry up to 60 tons of ore per hour. Two disadvantages of the rotary dryer are, the heat loss due to radiation, and the fibre damage caused by the cascading action of the ore.

The stack dryer is a vertical shell up to 50 feet in height and about 7 feet in internal diameter. At intervals within the stack, which may be circular or rectangular in cross section, are fitted deflection bars, which retard the fall of ore. The ore is introduced at the top and descends through a rising stream of hot air introduced at the bottom. The advantages cited for the stack dryer are;[5]

(a) Lower operating and repair costs as there are no moving parts other than the bucket elevator or conveyor belt used to feed the ore at the top.

(b) Less heat loss.

The overall cost in drying similar type of ore is said to be up to 1/3 less as compared to rotary dryer.

It is not necessary to completely dry the ore in the dryers as the retained heat will complete the process in the main stock pile.

Stock pile.

The stock pile is an important factor in the present milling practise. One purpose is to allow the ore to cool and mature to a con-

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(5) J. G. Ross - Chrysotile Asbestos in Canada, p. 44

stant low moisture content which is important in the regulation of the subsequent milling procedure. These stock piles, of many thousands of tons, also serve as a steady source of mill feed. The reserve is quite important in open pit mines as mining may be seriously curtailed or interupted by bad slides or inclement weather during the winter months.

Secondary crushing

The ore is withdrawn from the stock pile and fed to secondary crushers, usually a cone or gyratory crusher, with discharge set at approximately $1\frac{1}{2}$". Undersized material is removed, either by grizzly or by vibrating screens, before the ore enters the secondary crushing unit. Discharge from the crusher joins the undersized previously screened out and the ore then passes over vibrating screens. Minus one inch material passes over shaking screens and the first fibre is removed. Plus one inch is passed to another crushing unit and joins the material not lifted by suction from the first set of screens. As strong suction is usually maintained on the first lift, considerable sand is raised along with the fibre. This dirty product is again screened to remove the sand, with the fibre being removed by suction from the end of the shaker screen.

Fiberizer

From the secondary crushing unit and the first screen, the coarse material and sand are passed through a progressive series of fiberizers, with shaking screens and suction lifts to remove the released fibre after each fiberizer. The function of the fiberizer is to break the small rock fragments by impact, and to open or fluff the fibre, with a minimum of damage, so that it can be lifted from the subsequent screen by suction fans. Essentially a fiberizer consists of a horizontal or vertical stationary drum, 6 ft. to 8 ft. long, and 2 ft. to 3 ft. in diameter. A shaft along the longitudinal axis, has beater arms attached at 6 inch to 8 inch intervals. Each arm has a chilled cast iron head bolted to its end and bevelled towards the discharge end of the fiberizer. The shaft, with attached beater arms, rotates from 1000 to 1600 r.p.m. depending on the character of the feed and the product desired.

One advantage of these beater type fiberizers is that most of the breaking is done by throwing the rock fragments against each other or against the shell, resulting in a minimum of grinding action. Nevertheless, much harm is done to the fibre, but at present no other satisfactory method has been developed to replace these machines.

Screening and Collecting

The discharge from the fiberizer is conveyed by belt to shaking screens where coarse sand is removed. An eccentric drive gives the inclined screen a thrusting and bumping motion which not only maintains a flow of material down the screen, but also causes open fibre to work itself to the top of the flow where it can be easily picked up by suction. A hood suspended over the end of each screen is connected by pipes to a collector. This consists of a large circular bin; the top portion is cylindrical and covered at the upper end; the lower portion tapers from the cylinder to a cone, the apex of which is a pipe forming the discharge of the collector. Extending downward from the cover of the cylinder to about the top of the cone, is a central pipe leading to the exhaust chamber of the collector. Between this central pipe and the outer cylinder wall are baffles. The outlet chamber is connected to a large multi-bladed exhaust fan, which creates a vacuum within the collector, thus sucking the loose fibre from the screens into the collector. Within the collector the velocity of the air currents is greatly reduced. This drop in velocity, plus the dampening effects of the baffles, allows the fibre to fall to the bottom of the cone, where it is drawn off. The air is drawn up through the central pipe into the exhaust chamber and out through the fan. This air carries very fine fibre and dust called "floats" which are collected and sold as one product of the mill.

If the screen carries a heavy load of fibre, a second hood may be suspended over it, at about half way down. Both hoods are connected to the same collector. If there are a number of screens producing the same product, these are connected to the same collector. Figure lV shows a shaking screen and hood; Figure V shows a battery of collectors, with the exhaust fans in the background.

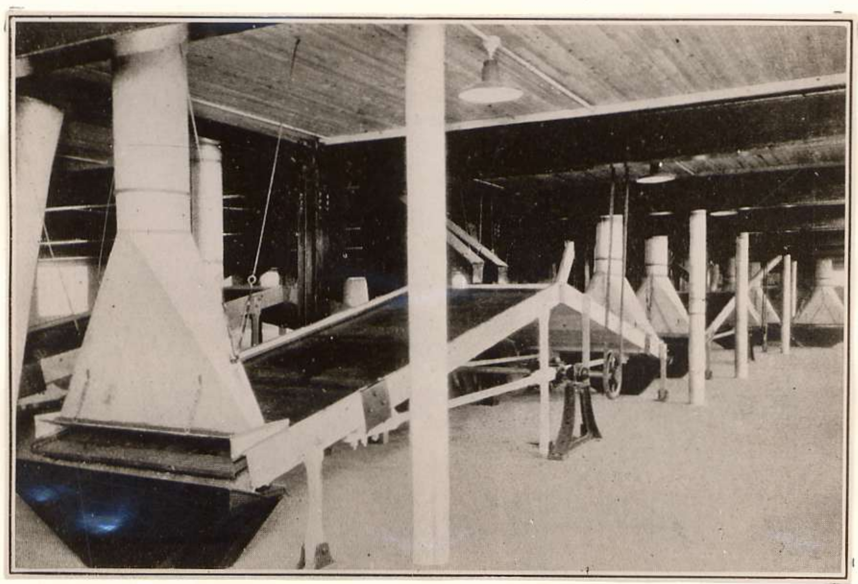

Fig. lV Shaking Screens and Hood.

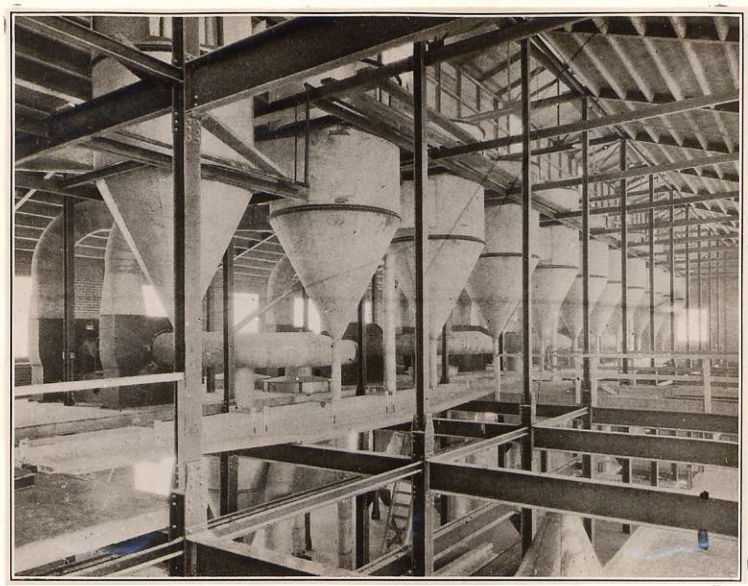

Fig. V Collectors.

The fibre from the collector is dropped through pipes to a grading screen, where the various grades are separated.

Discharge from the shaking screen, consisting of fibre still attached to rock, is passed on to another jumbo or fiberizer and the process of fiberizing, screening, collecting and grading is repeated. Each succeeding repitition of this process usually produces a series of lower grade, i.e. short lengths, fibre.

SUMMARY

The theme of the asbestos mill is separation of fibre from rock by successive stages of crushing and fiberizing, with screening of sands and removal of fibre from the circuit after each fiberizing.

Ore from the mine is first primary crushed, picked for crude, dried and stock piled. Mill feed from the stockpile is passed through a secondary crusher. It is then fiberized, screened, the fluffed fibre vacuum collected and graded. The screen discharge is treated further until the limit of economic recovery is reached. The steps are basic but the manner in which they are executed is a matter of careful engineering and fine judgment. In every step care must be taken to minimize unnecessary fibre damage.

Grading and Testing Asbestos Fibre.

Grading of fibre is done in accordance to a standard scale. This scale is based essentially on the fibre length, and has been accepted and is used exclusively by both producers and manufacturers in North America. By this scale, fibres are classified into nine groups, as follows:[6]

Crude Asbestos

Class	Standard designation of grade	Description
Group No. 1..	Crude No. 1..........	Consists basically of crude $\frac{3}{4}$-inch staple and longer.
Group No. 2..	Crude No. 2..........	Consists basically of crude 3/8-inch staple up to $\frac{3}{4}$-inch.
	Crude run-of-mine....	Consists basically of unsorted crudes.
	Crudes sundry........	Consists of crudes other than above specified.

(6) J. G. Ross. Chrysotile Asbestos in Canada pp. 50-51.

Milled Asbestos

Group No. 3....	Spinning or textile fibre,	Consists of fibre testing 0 - 8 - 6 - 2 and over
Group No. 4....	Shingle fibre......	Consists of fibre testing below 0 - 8 - 6 - 2 to and including 0 - $1\frac{1}{2}$ - $9\frac{1}{2}$ - 5.
Group No. 5....	Paper fibre........	Consists of fibre testing below 0- $1\frac{1}{2}$ - $9\frac{1}{2}$ - 5 to and including 0 - 0 - 8 - 8.
Group No. 6....	Waste, stucco or plaster.	Consists of material testing below 0 - 0 - 8 - 8 and above 0 - 0 - 5 - 11.
Group No. 7....	Refuse or shorts...	Consists of material testing 0 - 0 - 5 - 11 and below, including material testing below 0 - 0 - 1 - 15 and specified as weighing 35 pounds or less per cubic foot, loose measure.
Group No. 8....	Sand..............	Consists of such asbestos mill products as sand, weighing over 35 pounds per cubic foot, loose measure, and under 75 pounds per cubic foot, loose measure and containing a preponderance of rock.
Group No. 9....	Gravel and stone...	Consists of such asbestos mill products weighing 75 pounds and over, per cubic foot, loose measure.

Determination of mill run grade is done by taking test samples every half hour or so at the place of each bagging operation and at the grading screens. The sample is tested in a standard testing machine, a description of which follows: [7]

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(7) J. G. Ross. Chrysotile Asbestos in Canada p. 49

"The machine consists of a nest of four wooden boxes, measuring $24\frac{1}{2}$ by $14\frac{3}{4}$ inches and $3\frac{1}{2}$ inches in depth. The boxes, which are superposed one above the other, are numbered from the top down 1, 2, 3 and 4. The bottoms of boxes Nos. 1, 2 and 3 are made of metallic screen of the following specifications: Box No. 1: $\frac{1}{2}$-inch opening, diameter of wire, 0-105 inch. Box No. 2: 4-mesh wire, 0-063 inch. Box No. 3: 10-mesh wire, 0-047 inch. Box No. 4: is a receptacle for the fines which fall through the three other boxes. The nest of four boxes or trays rests on a table to which an eccentric with a throw of $\frac{25}{32}$ - inch gives a movement of 1 9/16-inch travel."

"To make a test, 16 ounces of asbestos is put on the top tray which is covered. The machine is run at the rate of 300 r.p.m. at the shaft of the eccentric, and by means of an automatic device, this is kept going for exactly two minutes, giving the nest a horizontal shaking movement. At the end of this time, the asbestos which remains on each tray is weighed. This gives the grades of the asbestos fibre; the longest fibre naturally stays on the top tray, whereas the shorter fibre, according to its length, remains on screens 2 and 3 or drops into the pan or lowest tray. The more fibre retained on the first screen and the less fibre in the pan, the higher the grade and therefore the greater its value. If for instance a customer buys spinning fibre of the specification 4-7-4-1, it means that in a sample of 16 ounces, representing the average of the lot shipped, 4 ounces will remain on the top screen, 7 on the second, 4 on the third and finally 1 ounce will go through all the screens into the pan."

Commercial Uses of Asbestos.

To compile a general list of the uses of asbestos would be a formidable task. To obtain a comprehensive conception of the application of asbestos to industry, building trades and commerce, it is necessary to study the catalogue "Asbestos" published monthly by the major asbestos companies. Products in which asbestos is used, seldom give any visual indication of the asbestos content, and for this reason few people realize the important place this mineral occupies in industry today.

The No. 1 and 2 crude and No. 3 spinning groups are used either alone or with some admixed cotton, to spin into yarn, and weave into cloth, which finds use in theatre curtains, fire fighting blankets, fire fighting suits, helmets and gloves, wall linings, gaskets, braking linings, high temperature packings, wrappings for insulating jet engines and many other uses. A low iron content fibre is an essential for high voltage electrical insulations on wire and cable and has preferred listing as essential stock piling for emergency by the U. S. Navy.

Groups 4 to 7 are used in a wide range of manufactured products, a few of which are: asbestos paper, mill boards, wall boards, roofing papers and shingles, asbestos cement sidings, preformed structural members, plastics, floor tiling, high temperature pipe insulations, insulation in kitchen appliances, refractory linings, etc. A recent development is asbestos cement or transit pipe finding wide use in industry and in municipal water systems.

Several of the asbestos minerals, less suited for general industry, have specialized uses. Amosite is used as a good light weight bulky filler. Crocidolite has excellent gas filtering properties, and among other uses is found in specially prepared form in cigarette filters and in "cork tipped" cigarettes. Tremolite has pharmacutical applications and is used in chemical filters and in the preparation of blood plasma.

W O R K S C O N S U L T E D

J.G. Ross. Chrysotile Asbestos in Canada

Asbestos, Philadelphia, March 1952 to Oct. 1953

M.S. Badollet, C.I.M. Bull. Vol.46 No. 496
(Aug. 1953) pp.477-479

M.S. Badollet, C.I.M. Bull. Vol. 44 No.468
(Apr. 1951) pp. 237-246

	CHRYSOTILE	CROCIDOLITE	AMOSITE	ACTINOLITE	ANTHOPHYLLITE	TREMOLITE
SPECIFIC GRAVITY	2.4 - 2.6	3.2 - 3.3	3.1 - 3.25	3.0 - 3.2	2.85 - 3.1	2.9 - 3.2
FUSIBILITY	Fusible at 6	Fusible at 3	Fusible at 6. Loses H_2O at moderate temperatures.	Fusible at 4	Difficultly Fusible.	Fusible at 4.
FLEXIBILITY	Very Flexible	Fair to Good	Good. Less than Chrysotile.	Brittle and Nonflexible.	Very Brittle. Nonflexible.	Generally Brittle Sometimes Flexible.
LENGTH	Short to Long.	Short to Long.	2" to 11". Varies.	Short to Long.	Short.	Short to Long.
TEXTURE	Soft to Harsh also silky.	Soft to Harsh.	Coarse but somewhat pliable.	Harsh.	Harsh.	Generally Harsh Sometimes Soft.
TENSILE STR'TH	Very Good	Very Good. Highest of all Varieties.	Fair. Less than Chrysotile.	Very Weak.	Very Weak.	Weak..
ACID RESISTANCE	Soluable up to approximately 57%	Fairly resistant to Acids.	Fairly Resistant	Relatively insoluable in HCl.	Fairly Resistant	Fairly Resistant.
SPINNABILITY	Best	Fair.	Fair.	Poor	Poor.	Generally Poor. Some are Spinnable.

Table 1 Properties of Asbestos Minerals[1]

TYPE OF MATERIAL	TENSILE STRENGTH (Lb./Sq. In)
Wrought Iron.	48,000
Carbon Steel	155,000
Piano Wire Steel	300,000
Cotton Fiber	73,000 to 89,000
Glass Fiber	100,000 to 200,000
Chrysotile Asbestos	80,000 to 100,000
Crocidolite Asbestos	100,000 to 300,000.
Amosite Asbestos.	16,000 to 90,000
Tremolite Asbestos	1,000 to 8,000.

Table 2 Comparative Tensile Strength of Common Materials[2]

(1,2) M.S. Badollet, C.I.M. Bull. Vol. 44 No. 468 (Apr. 1951) p. 241