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SEPTEMBER 1960

Bulletin No. _____

A. R. P.

ASBESTOS REINFORCED PLASTICS

Introduction

History

Fiber Characteristics

Plastics Characteristics

References

Prepared by - Asbestos Committee

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New York 17, New York

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INTRODUCTION

This bulletin provides industry with current available information and data concerning the use of asbestos as a reinforcement in "reinforced plastics". A.R.P. (Asbestos Reinforced Plastics) provides industry with materials capable of meeting various properties or requirements.

Typical ARP Properties or Requirements

Heat Resistance
Low thermal conductivity
Chemical Resistance
Cryogenic Resistance
High stiffness (E)
High mechanical strength
Varying electrical characteristics
High toughness

"Premix compound ingredient
Gunk molding compounds"

Typical ARP Products

Cooking handle utensils
Switchboards
Electric Motor Casing
Lamp Sockets
Domestic & Industrial electrical panels
Commutator Rings
Cable insulators
Auto body & Railway body parts
Housings for auto heaters & air conditioners
Underground conduits
Sewer pipes
Noise insulators
Helmets
Gun grips
Incinerators
Blackout or bombproof shelters
Missile nose cone
Rocket motor structures and insulation
Missile blast tubes
Brake linings
Friction materials for automatic equipment
Clutch facings
Gaskets
Valves
Roofing
Acid proof tanks
Gas vent tubes or pipes
Aircraft ducting
Chemical Filters

This bulletin does not discuss fiberglass or glass fiber reinforced plastics which represents a large and continuing growing industry. The subject of glass fiber has been reviewed in numerous SPE bulletins and literature. Also, this review does not include discussions on other fiber used in "reinforced plastics"; such as, cotton, nylon, rayon, sisal, quartz, aluminum silicate, etc.

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The principal reasons for preparing this bulletin are attributed to the growing demand for A.R.P. and that an education is required in better understanding asbestos as applied to reinforced plastics. Raw asbestos can introduce a multiplicity of problems if its variables are not understood. These variables include conditions such as chemical analysis, grading, classification, and trading conditions. Various specifications are available, but it has been determined in certain industries where A.R.P. is used that new specifications for the use of asbestos in reinforced plastics will gradually evolve based on new industry requirements.

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HISTORY

Asbestos has been one of mankind's most "creative" materials. Engineers and chemists have continually used asbestos in the manufacture of many different products. In the past 2,000 years asbestos has been used for many diversified products and applications. Serious use of asbestos occurred during the turn of the last century. It's uses, scientific and general, have become extensive in many spheres and new uses are constantly found for it.

It's use is usually classified according to the type of product. Groupings such as building materials, plastics, textiles, and heat insulators are sometimes used; however, products can overlap in these main groups - as an example, an asbestos paper product can be used for heat insulation and also in building construction. To some people the word asbestos only identifies a fireproof cloth.

Asbestos occurs in rock masses. These fiber-bearing rocks provide for fibers of various lengths. The shorter fibers are more abundant than the longer ones. They are used in the largest single asbestos industry; namely, cement products such as siding shingles, flat sheets, roofing shingles, and corrugated sheets.

The longer fibers are primarily used to manufacture textile products such as yarn, cloth, tape, felt, and lap. The textile industry is reported to constitute the second largest use for asbestos but generally lose their identity since they go into other products. Principal source or method of obtaining asbestos for the textile industry involves hand picket operations at the mine. Special fiberizing processes at the textile mill are of prime importance in manufacture of textile products.

Textile asbestos products are used in different fields including textiles, packings, gaskets, plastics, brake linings, filters, electrical cables, and thermal insulators.

General Features

The importance and commercial value of asbestos is attributed to it's incombustibility and it's unique fibrous structure. It is a spinnable or filling agent, unburnable rock, created by nature by such a process that man has not been able to reproduce it in this highly scientific world. It is a mineral silk, undecayed and unaltered by time or weather.

Asbestos has the characteristics of silk or cotton, but it will not burn. Asbestos is a great enemy of heat, flame, chemicals and acids. It is resistant to moisture and corrosion.

Asbestos fibers can be individually fiberized and handled similar to other fibers such as animal origin (wool and silk, etc.) and those of vegetable origin (cotton, flax, etc.).

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To the physicists and scientists, asbestos being both fibrous and crystalline, makes it a wondrous material. This rock type material is a natural scientific product which has become indispensable to mankind since it is used in many different fields of industry.

The Greek word asbestos means indestructible, unquenchable and eternal. It has been found in almost all parts of the globe, including Canada, Italy, U.S.A., South and Central America,

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China, Japan, Spain, Newfoundland, Australia, Portugal, Hungary, Russia, Central Africa, and Southern Africa. Commercial value is principally concentrated in the areas of Canada, Russia, Central Africa and South Africa. The Canadian asbestos is generally considered to be superior to others insofar as essential properties of infusibility, tensile strength, fineness and elasticity is concerned.

Origin

Many theories exist concerning the formation of asbestos. The theories basically differ depending on the source of information. Even though asbestos has been known for ages, it's geological history and formation are still matters of conjecture.

One of the theories involve the result of volcanic activity which occurred many hundreds of thousands of years ago. The igneous rocks had acidic intrusives that formed granites and feldspar-dikes. The ultra-basic intrusives formed dunite which eventually formed peridotite and pyroxene peridotie after coming in contact with olivine and oxides. Through the ages these rocks passed through various stages of physical and chemical changes to form minerals known as serpentine. This change occurred during the time when pressure was created on the rocks causing cracks in the rock. In turn, these cracks were filled with hot ground waters derived from the infiltration of rain or surface waters. The continual infiltration of this water under heat and pressure acted as a solvent. The water became contaminated with different minerals. Crystals developed and were deposited in the cracks of the rock.

Most rocks are made of crystals. Crystals hold one of the most secret of all nature's mysteries. These crystals form basic patterns. The minerals which make up the crystals are important and produce the specific different type asbestos fibers.

The rock formation in Canada is a variety of the olivine which is composed of iron, magnesia, and silicate. Water containing carbon dioxide and salt in solution penetrated the rocks. This gradual flow of highly contaminated mineral water changed the original rock from iron - containing mineral to magnesia - silica - water. According to the geologist, this reaction took place thousands of feet below present elevation.

Since it is believed that asbestos developed deep within the earth where it could be subjected to pressure and heat, it is believed that in the case of the North American Continent, the glaciers or massive ice formation eventually removed the earth and exposed asbestos on the surface of the earth.

During the formation of asbestos with the continual pressure reportedly moving the rock formations and causing rocks to crack, the crystals or fibers developed various patterns in the cracks. The resultant veins of asbestos rock were predominately broken so that more of the short asbestos fibers are available.

Ore Deposits

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Asbestos is made available to industry either directly from the mines or through distributors. At least 90% of the asbestos is obtained directly from the mines. Most of the asbestos

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companies which mine asbestos, use the asbestos to produce products with secondary interest in supplying raw asbestos to other companies. There are also manufacturing companies which specialize in the manufacture and production of asbestos products without directly owning mines.

The United States is the World's largest producer of asbestos products. The main source of asbestos for the United States is Canada. The Canadian mines are favorably located for supplying the United States consumers. Canada provides approximately 90% of the asbestos used. Domestic asbestos contributes approximately five percent.

The enormous territory of USSR contains asbestos deposits to such an extent that they should be considered one of the principle producers of asbestos in the world. These deposits are generally considered second of importance to the Canadian. Prior to World War I, Russia occupied second place among the world's asbestos producers. Its largest asbestos mines are situated in the Ural Mountains. Deposits also exist in Siberia.

Grading

With the gradual progress in developing highly engineered products with asbestos, the asbestos industry has required the mines to set up special methods of classifying asbestos in accordance with length of fiber.

Exact measuring of actual staple length of asbestos fiber is one of the more difficult tasks by the manufacturer. Asbestos differs from cotton, rayon, and other fibers which are possible to comb. By combing the fibers, the actual length can be measured. Staple length of chrysotile asbestos fibers of any one of the various types varies from 3/8" to 1" and down to microscopic measurements.

Grading of asbestos is generally on the basis of length rather than quality. Qualities which are also important to the fibers in addition to length are flexibility and fineness. The more flexible and fine fibers are used for spinning and weaving textile products. The shorter milled fibers are used in various products such as asbestos cement, tile, and brake linings.

In 1931, a committee was organized by the Minister of Mines of the Province of Quebec. The committee on "Uniform Classification and Grading of Asbestos Mines Products" had the project of revising the chrysotile asbestos grades.

The Canadian Asbestos Producers have set up what is referred to as "Quebec Standard Asbestos Testing Machine" for classifying milled asbestos. This method is based on the mechanical sieving of fibers. There has been a general trend to adopt the Canadian Standards Classification; however, many of the old mines in Canada still retain their own methods which are specifically tailored to their customers. The classification divides chrysotile into two main classes of crude and milled asbestos.

The Crude Asbestos consists of the hand selected cross-veining material essentially in it's native or unfiberized form. The Milled Asbestos consists of all grades produced by mechanical treatment of asbestos ore. These two main divisions are sub-divided into different groups ranging from group No. 1 to No. 9.

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Classification of chrysotile asbestos according to Groups are as follows:

Crude Asbestos

Group No. 1	Crude No. 1	Consists basically of crude 3/4 inch staple and longer
Group No. 2	Crude No. 2	Consists basically of crude 3/8 inch staple up to 3/4 inch
	Crudes, Run-of-Mine	Consists basically of unsorted crudes
	Crudes, Sundry	Consists of crudes other than specified above

Milled Asbestos

Standard Designation of Grades	Guaranteed Minimum Shipping Test			
Group No. 3 (Spinning Fibres)				
3D	10.5	-3.9	-1.3	-0.3
3F	7	-7	-1.5	-0.5
3K	4	-7	-4	-1
3R	2	-8	-4	-2
3T	1	-9	-4	-2
3Z	0	-8	-6	-2
Group No. 4 (Shingle Fibres)				
4D	0	-7	-6	-3
4H	0	-5	-8	-3
4K	0	-4	-8	-3
4M	0	-4	-8	-4
4R	0	-3	-9	-4
4T	0	-2	-10	-4
4Z	0	-1.5	-9.5	-5
Group No. 5 (Paper Fibres)				
5D	0	-0.5	-10.5	-5
5K	0	-0	-12	-4
5M	0	-0	-11	-5
5R	0	-0	-10	-6
Group No. 6 (Waste)				
6D	0	-0	-7	-9
Group No. 7 (Shorts or Refuse)				
7D	0	-0	-5	-11
7F	0	-0	-4	-12

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Group No. 7 (Shorts or Refuse) continued....		
7H	0 - 0 - 3 - 13	
7K	0 - 0 - 2 - 14	
7M	0 - 0 - 1 - 15	
7R	0 - 0 - 0 - 16	
7T	0 - 0 - 0 - 16	
7W	0 - 0 - 0 - 16	
Group No. 7 (Floats)*		
7RF	no test	
7TF	no test	
Group No. 8 (Sand and Gravel)		
8S	Under 50 pounds per cubic foot loose measure	
8T	Under 75 pounds per cubic foot loose measure	
Group No. 9		
9T	Over 75 pounds per cubic foot loose measure	

*The suffix "F" designates "Floats" in the case of the 7R and 7T grades.

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In the Group No. 1 and No. 2 the length of the Crude asbestos can be measured by means of combing. In the case of the milled asbestos, the Quebec Standard Testing Machine is used. It consists of three stacked screens and a pan resting on a table. These screens are driven by an eccentric gear so that an ellipitical motion is produced on the screens. Each screen measures 24-1/2 inch x 14-3/4 inch with the boxes each 3-1/2 inch in depth. The top box which is identified as Box 1 consists of a wire screen with 1/2 inch openings, Box 2 has a 4-mesh wire, Box 3 has a 10-mesh wire and Box 4 is a closed receptical which collects all matter filtered through the other three boxes. The motion of the boxes and the time that fibres are subjected to motion are fixed.

The test procedure is to introduce 16 ounces of asbestos on the top tray. After two minutes of motion, the fibre in each tray is weighed.

The more fibre retained on the first screen and the less fibre falling into the pan produces a higher grade product. As an example, Group No. 3K specifies 4-7-4-1. This means that in a sample of 16 ounces, Box No. 1 retained 4 ounces, Box 2 retained 7 ounces, Box 3 retained 4 ounces and one ounce fell in the bottom pan.

The Quebec Asbestos Mining Association has set up standard testing procedures which include the use of a standard approved machine. They specify the method of taking samples for testing. When testing Group No. 3 fibres, a composite sample shall be made up from each and every lot of 100 bags included in the number to be tested. Each composite sample shall be made up by taking a handful (about 4 ounces) from every fifth bag of the one hundred bags.

In the case of Group No.'s 4, 5, or 7 fibres, a composite sample shall be made up from each and every lot of two hundred bags included in the number to be tested.

Each composite sample so made up shall first be allowed to approximate average work-room temperature and humidity, and then shall be thoroughly mixed on a smooth topped table while passing it through the hands with a gentle rubbing action in order to break up and separate all clots and lumps. It is then divided into halves, quarters, etc., as necessary, and a represented one pound lot shall be weighed accurately and placed in the testing machine.

The greatest increase in use of fibres has been in the shorter lengths that comprise approximately 50 per cent of Canadian asbestos production. The classification of shorts and floats follows the same principals of the shaker test; however, other factors such as bulk, grit percentage, viscosity, etc., have a bearing on nomenclature used.

The Group No. 7 shorts or refuse consists of material testing 0-0-5-11 and below. The term refuse is a railway freight classification designation and does not mean that shorts and floats are by-products of asbestos milling. As the name implies, floats are fibres so fine and light that they are collected by air floatation. They are precipitated into float chambers by gravity settling or collected by filtering media.

Shorts and floats have shown a remarkable increase in use for several reasons: quality improvements which have developed new uses and improved finished products thus causing the shorter to supplement some of the longer fibre applications and the expanding markets for relatively new or growing industries such as vinyl tile, plastics, asphalts, and

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asbestos-cement.

Other methods of classifying fibres have different identifications depending on the type asbestos, length of fibre, fiberization, and other characteristics. In some cases, the mines add additional letters or numbers to the Quebec Standard Testing Machine nomenclature. As an example, the Asbestos Corporation, Ltd. includes a number system to designate degree of crudeness or openness.

Manufacturers of asbestos products obtain fibres from more than one source in order to eliminate potential problems inherent when only one source is available. Since asbestos fibres from different mines sometimes behave different in processes, the manufacturers have to keep close controls on manufacturing processes for the various type fibres. This is a skill obtained through continuous use of the different fibres.

The class and grade of asbestos used in the manufacture of different products vary; however, the general trend can be identified. Long fibres are used for yarn, cord, braid, and textiles; for packing and gaskets; fpr felted long fibre paper or felts, and for filtration; and asbestos-cement goods where maximum strength is required. The medium length fibres including Groups No. 3, 4 and 5, are used as reinforcing filler in asbestos-cement products; asbestos paper and millboard; as the bonding agent in magnesia insulating compounds, filtration pads and sheets and molded brake blocks and linings. The short fibres and floats are used as fillers in paints, asphalt, puttys, plaster, stucco, plastic moldings, and others.

The Group No.'s 8 and 9 generally contain large portions of minute rock and sand which are not detrimental to the finished products.

In Northern British Columbia, the Cassiar asbestos grades are identified as follows:

Crude #1 - Basically of crude 3/4" staple and longer
AAA - Extra long textile fibre
AA - Long textile fibre
A - Textile fibre
AC- Long shingle fibre
AK- Medium long shingle fibre
AS- Shingle fibre
AX- Short shingle fibre

Asbestos producing countries other than Canada do not use the Quebec Testing Method. Their designations do not tally with the Quebec Classification. If material from another country were tested on the Quebec machine, there would only be a comparison of relative value but never an exact comparison according to grades. Classification of asbestos fibre available from different parts of the world are reviewed.

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Classification of African Chrysotile

C&G1	Long, crudy textile fibre	From mines in the Shabani district of Southern Rhodesia
C&G2	Textile fibre	
C&G3	Long shingle fibre	
C&G4	Shingle fibre	
C&G5	Short shingle fibre or paper stock	
VRA/-2	Textile fibre	From the Mashaba district of Southern Rhodesia
VRA/-3	Long shingle fibre	
VRA/-4	Shingle fibre	
HVL/2	Textile fibre	From the Havelock Mine in Switzerland
HVL/3	Long shingle fibre	
HVL/4	Shingle fibre	
HVL/5	Short shingle or paper stock	
Msauli - Grade 4	Shingle fibres	From the Msauli Mine near Swaziland border in the Transvaal
Msauli - Grade 5		

Classification of Russian Chrysotile

Grade	Type	Texture	Mark According to U.S.S.R. Standard January 1, 1952
1	Textile	Hard (crudy)	J-1
2	Long shingle	Hard	J-2
		Semi-hard	P-2
3	Shingle	Hard	J-3
		Semi-hard	PJ-3
			P-3
		Soft	M-3
4	Short shingle & paper stock	Hard	J-4
		Semi-hard	P-4
		Soft	M-4
5	Paper Stock	Hard	J-5
		Semi-hard	P-5
		Soft	M-5
6		Hard	J-6
		Semi-hard	P-6
		Soft	M-6
		Unguaranteed	K-6
7		Unguaranteed	K-7
			7-370
			7-450
			7-520

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Classification of Russian Chrysotile

Grade	Type	Texture	Mark According to U.S.S.R. Standard January 1, 1952
8		Unguaranteed	8-750

Classification of Australian Chrysotile

Grade 4 - 2 inch fibres and longer
Grade 3 - 1 inch to 2 inch fibres
Grade 2 - 1/2 inch to 1 inch fibres
Grade 1 - 1/4 inch to 1/2 inch fibres

Classification of African Amosite

Group 1	-	Produced from hand-selected long fibre at Penge Mine only.
D3	-	Long - over 3" in length
Group 2	-	Produced at Penge from run-of-mine fibre after longest has been hand-selected.
D11	-	Minus 3" plus 3/4".
DX	-	As above but graded by color.
Group 3	-	Generally minus 2-1/2" plus 5/8"
MD	-	From Penge mine
M	-	From Penge mine - somewhat shorter
W3	-	From Weltevreden Mine
K3	-	From Kremellenboog Mine
Group 4	-	Generally minus 1/2"
S2	-	From Penge Mine
SK	-	From Kremellenboog Mine
SW	-	From Weltevreden Mine
Group 5	-	Generally minus 1/2"
GW	-	From Weltevreden Mine
GK	-	From Kromellenboog Mine

In addition to the above grades there are several from the Pietersburg Field, of which WEG from the Malipedrift area is probably the most uniformly prepared. The latter is similar in length to Group 3.

The other grades listed in the foregoing grouping are produced in the Penge area, of which the Amosa Mine is the largest producer. The screen sizes shown are not necessarily exact, but have been included in order to give some indication of the relative lengths of fibres of the different grades:-

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Cape Blue (Crocidolite)

E - plus 2-1/4 inches
D - plus 1-3/4 - 2-1/4"
C - plus 1-1/4 - 1-3/4"
No. 1 or B - plus 3/4" - 1-1/4"
No. 2 or A
and R2 - plus 1/2" - 3/4"
No. 3 or S
MS and R_3 - plus 1/4" - 1/2"
X, SBG, H and SS - Various shorter grades

Of the foregoing, the longer grades down to No. 2 or A are mostly hand-cobbed.

Transvaal Blue (Crocidolite)

TX - Plus 1-1/2"
T_1 - " 7/8" - 1-1/2"
T_2 - " 1/2" - 7/8"
T_3 - 1/4" - 1/2"
"Long" - MLS and NC300 about 1/4 to 3/8"
T_4 - and "shorts" mostly minus 1/4"

Most of the above numbers have fallen into disuse. The present practice is to refer largely to "long" and "short" for the bulk of the Transvaal production. There is no recognition among the major producers that greater standardization is desirable.

Australian Blue Grades

No. 1 Long fibre - 1 in. and over
No. 2 Plus 3/8 to 1 in.
No. 3 Minus 5/8 in.

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Mining, Milling and Processing -

The method of mining, milling and processing of asbestos depends on the type of asbestos being handled as well as it's specific physical characteristics such as a soft versus harsh fiber. Since Chrysotile fiber accounts for approximately 95% of all the asbestos used, this discussion will pertain to Canadian chrysotile.

Originally, when the mines were opened, the mining operation involved predominately manual labor in open pit operations. In the past thirty years the mining operations have become highly mechanized with the use of cranes, cable hoists, etc.

Hand cobbing is the oldest method used in mining asbestos. This particular method is still used to obtain the long asbestos fibers. The operation involves releasing fiber from the rock by means of hammering away the rock from the ends of fibers. Fibers identified as crudes #1 and #2 are hand cobbed. These type fibers are not processed through the standard crushing units during the milling operation of the shorter fibers.

The content of fiber in the rock mine ranges between 3% to 10%. Workable mines are considered profitable when the recovery is only 3% of raw asbestos. Variables such as availability of labor, transportation facilities and size of deposit determine whether a low asbestos content mine will be profitable. In Canada rich areas are considered to recover approximately 5% to 12%.

The asbestos, as obtained from the mines by blasting and quarrying, is sold either as "Crude" or "Milled". Crude asbestos consists of hand-picked asbestos in it's natural unfiberized condition. The Crude generally contains 5 to 15% rock, dust or short fiber which has to be removed by the manufacturer in their own plant.

The Milled asbestos is made up of the shorter fibers. Different processes or systems are used by the mines to process the milled fibers in order to release rock and fiberize bundles of fibers.

Asbestos fiber is found in rock deposits classified as cross-fiber, slip-fiber and mass-fiber. Asbestos usually occurs as cross-fiber in which the fiber runs at relatively right angles to the walls of the rock. The fiber length rarely exceeds 2 t· 3 inches. The average long fiber asbestos for chrysotile is 3/4". In some cases a bend occurs in the fiber which results in a weak fiber at the point of bending.

In slip-fibers, the fibers lie in the direction parallel to the seam or crack in the rock. Generally, this type fiber is weaker than the cross-fiber. It is considered unsuitable for spinning.

In the mass-fiber classification, there is a complete absence of any orientation of fiber. The asbestos is distributed at random. This type of formation generally occurs with the amphibole varieties of asbestos. The fibers tend to be soft.

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When large cross-fiber veins occur it is relatively simple for a miner to hand cobb in order to obtain crude fibers. The long fiber adhering to rock is sometimes dried over steam coils in order to simplify extraction of the fiber from the rock.

Most of the fiber veins are too narrow to be separated profitably by hand. The rock containing asbestos is sent to a mill located near the mine whereby mechanical means separation is accomplished.

The proportion of long fiber or crude asbestos extracted from the rock is approximately 8 to 10% of the asbestos which is removed. The remaining asbestos consists of medium and short fibers. Markets in industry exist for all lengths of fiber.

It is difficult to ascertain the true value of a mine by only spot checking. The width of an asbestos vein at any one point does not provide a true picture of the length of fiber which it contains. To obtain reliable values it is necessary to remove or blast the rock from many different locations.

The mining experts judge the various types and grades of asbestos according to length and softness of fiber. Other properties are also taken into consideration since various type asbestos conditions are desired for the specific end products involving fabrics, brake linings, packings, asbestos-cement, and others.

Since most of the asbestos mines are located in mountaineous or rough terrain, an important consideration in developing a mine is to determine the availability and transportation costs of the asbestos to the customer. Another major consideration is to set up proper operations involving the hauling of large quantities of rock. Many asbestos mines handle tons per hour of material or ore. This high tonnage rate is necessary since the yield of the average asbestos mine can be less than 5%. Mining requirements are such that the short asbestos fibers tend to become the most profitable products.

Two methods of mining exist. The open pit mines is the more desirable method. To open a quarry or open-pit mine, it is first necessary to remove surface matter. After removal of surface matter standard blasting techniques are used to loosen the asbestos containing rocks.

Underground mines are used. Various methods of tunneling are used.

Open-pit operations are performed by methods such as side hill cut, overhead cableways, spiral benching, multiple benching, and others which are generally identified by the physical method of mining. With a hillside exposure, mining the ore is a simple and cheap operation. It is mined in terraces cut out from the rock and in caves. This type of operation is found principally in the rich asbestos deposits.

The overhead cable operation is used in wide and deep pit mines. Carriages which remove the ore are connected to hoists. In turn, they are connected to track cables which are installed over the open-pits. It is reported that the largest commercial cable way system ever installed was at the King Mine of the Asbestos Corporation, Ltd., at Thetford Mines, Quebec.

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Spiral and multiple benching is related to the more conventional open pit method identified as inclined cable or truck haulage technique. In the inclined cable operation, the floor of the mine is inclined to the surface. When cables are used, the inclined angle is approximately 20 degrees. For truck operations, the angle is approximately 15 degrees or less. In the spiral benching operation, the pit develops into the form of a large bowl. The multiple benching technique is used where spiral benching is not feasible. Generally, barren rock formations are located in the large asbestos deposit or areas. The barren rock formation does not permit continual spiral operations so that different spiral benching operations occur in the one area. This type of operation is referred to as multiple benching.

Underground mining operations occur and generally tie in with open pit operations. Different techniques are used.

In most cases, mines are developed where asbestos occurs on the surface of the ground. New methods of finding asbestos deposits are being developed in order to find asbestos ore not exposed to the surface.

In mining operations wood is not used because contamination would be detrimental to the manufacturing plants.

Milling Asbestos -

After the asbestos ore is mined, the material goes through repetitive crushing operations to separate the asbestos and rock. Crushing and screening operations occur. These operations are referred to as "milling". Special mill equipment is required for these operations. The methods used in the various mines are basically the same but generally differs in regard to size which depends on mine capacity and type of fiber.

In milling the two major objectives are to separate asbestos from the rock and prevent reduction in the length of the asbestos fiber. The value of asbestos fiber depends mainly on fiber length. The objective of preventing reduction in length is vital. Extraction of the fiber from the rock requires repetitive crushing of the ore. After each crushing operation, free fiber is removed by air-suction.

In order to successfully remove asbestos, the material must be dry. The mined asbestos contains moisture which varies depending on weather conditions and season of the year. The moisture is removed by means of mechanical driers. The dry fiber can then easily be removed by air-suction.

The primary crusher, usually of the jaw type, has the capacity to handle rocks up to 48" in size, weighing up to a ton or more, and crushing them to approximately 5" to 6" in width.

Crushed rock is carried to trommel screens. These screens are large revolving cylinders with various size openings. The trommel screens only permit the relatively small rocks of approximately 5" to 6" width to continue through to the secondary stage of crushing. This type crusher is generally a gyratory or cone type crusher.

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Crushed rock is dried in tower or rotary driers which vary in temperature from 200°F. to 1,000°F.

After the drying operation the rocks which range in size from 2" to 3" are fed into a third crushing unit which is either of the gyratory type or cone type. The crushed ore and fiber are fed to heavy shaker or bumper screens which are operated by means of eccentric drives. Powerful air suction hoods remove fiber. The rock passes over the end of the screens. The undersize materials pass through the screen and is fed to a fiberizer for further treatment.

Additional shaking screens are used to separate fibers into long, medium and short categories. Duplex shaking screens are used. The long fibers remain on the top of the screen. The medium fibers in the lower screen and the short fiber passes through both screens.

The rock which was passed over the end of the heavy shaking screens continues to other crushers. The cycle is repeated whereby the crushed rock passes over shaking screens and in turn fiber is removed by air-suction.

After the fourth crushing cycle, the remaining rock is further separated by means of fiberizers. The fiberizers break the rocks by means of impact or direct blow of high speed hammers. The crushed stone is again fed through the shaking screen in order to remove additional fiber.

The milling operations are continuous. After the crushing and suction operations, the asbestos is cleaned, graded and put in bags for shipment. During the operation fiber collectors which are conical sylinders perform the first step in the cleaning operation. Currents of air carry the fibers into designated areas where additional cleaning can occur over screens.

The process of separating asbestos from rock during the milling operation takes into account the specific gravity difference of the two materials. After the fluffing or fiberizing operations, the dry asbestos can be taken away from the rock by means of air currents.

A method which is not generally used involves the wet-milling operation. In the wet-milling operation the fiberized asbestos will float on water.

Grading of asbestos fiber is conducted in special designed graders. Long rotary wire screens of various size mesh are used. The size mesh determines the length of fiber.

In general, the graded fiber is stored in burlap or jute bags of 100 lbs. The fibers are compressed in order to reduce bulk.

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Health and Safety Factors -

With the development of the asbestos industry, contamination of the air with small asbestos fiber particles produced hygienic problems. Hygienic measures were not well advanced when the first mining operations were developed. Since the dry processing method is used in mining and milling asbestos, small fiber particles are picked up by air currents and distributed throughout the manufacturing plants and in the neighborhoods. The asbestos particles or dust which developed could become harmful to the people who were constantly exposed to it. Asbestosis is a special type of silicosis but does not occur nearly as often. Approximately 10 years is required for a person to develop asbestosis if he is constantly exposed to the dust. However, since protective measures are provided by the different manufacturing plants, it is extremely rare that a person develops asbestosis.

Chemical analysis can be made of dust in order to determine concentration of asbestos dust particles. Information is available as to what the maximum concentration of dust should be to eliminate any problems. Various safety measures are available such as well ventilated areas, special masks, and water sprinkler systems. Proper filteration techniques are available which will collect dust particles.

With proper precautions, there is no problem. Periodic medical examinations of workmen are preformed in order to keep constant check on their health. Apparatus used in connection with the asbestos industry should be sealed off against outside air as much as possible and should work with a draft under negative pressure. The passage of the dust into lungs through the respiratory system is dangerous. It is important that proper precautions be taken by all companies which handle asbestos.

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