APTD-70

NATIONAL INVENTORY OF SOURCES AND EMISSIONS: ASBESTOS - 1968

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Air and Water Programs
Office of Air Quality Planning and Standards
Research Triangle Park, North Carolina 27711

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NATIONAL INVENTORY OF SOURCES AND EMISSIONS: ASBESTOS - 1968

by

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Publication No. APTD-70

PREFACE

This report was prepared by W. E. Davis & Associates pursuant to Contract No. CPA 22-69-131 with the U. S. Public Health Service, U. S. Department of Health, Education, and Welfare, National Air Pollution Control Administration.

The inventory of atmospheric emissions has been prepared to provide reliable information regarding the nature, magnitude, and extent of the emissions of asbestos in the United States for the year 1968.

Background information concerning the basic characteristics of the asbestos industry has been assembled and included. Process descriptions are given, but they are brief, and are limited to the areas that are closely related to existing or potential atmospheric losses of the pollutant.

Due to the limitation of time and funds allotted for the study, the plan was to personally contact about twenty percent of the companies in each major emissions source group to obtain the required information. It was known that published data concerning emissions of the pollutant was virtually non-existent.

The asbestos emissions and emissions factors that are presented are based on information obtained from production companies that represent about fifty percent of the domestic production, and from reprocessing companies that handled about five percent of the asbestos consumed in 1968. Two of the largest reprocessing companies refused to furnish the information requested concerning their facilities. At the beginning of this study, Johns-Manville indicated that they were willing to co-operate, but after several months and two special trips to their home office, no useful information was given. The GAF Corporation also indicated they would provide certain data but have delayed and have refused to grant permission to visit their mining facility in Vermont. This response was typical of several in the asbestos industry, and accounts for the lack of data from reprocessing companies. Many stated that they knew of no way to test for asbestos emissions and therefore could provide no information.

The magnitude of the asbestos emissions from production facilities is subject to many variables, including atmospheric conditions, and is very difficult to estimate accurately. The emissions during mining, blasting, loading, hauling, and unloading are virtually uncontrolled, and visual inspection indicates that emissions are substantial.

ACKNOWLEDGEMENTS

This was an industry oriented study and the authors express their appreciation to the many companies and individuals in the asbestos industry for their contributions.

We wish to express our gratitude for the assistance of the various societies and associations, and to many branches of the Federal and State Governments.

Our express thanks to Mr. C. V. Spangler, Project Officer, National Air Pollution Control Administration, for his helpful guidance.

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SUMMARY

The flow of asbestos in the United States has been traced and charted for the year 1968. The apparent consumption for the year was 817,363 tons and the domestic production was only 120,690 tons. Imports, mostly from Canada, totaled 737,909 short tons. There was no recovery from scrap.

Emissions to the atmosphere during the year were 6,579 tons. About 85 percent of the emissions were due to mining and milling operations. Estimates of emissions are based for the greatest part on observations made during field trips, and on the limited information provided by mining, milling, and reprocessing companies. Information was not available regarding the magnitude of the emissions or the particulate size.

There were no emission records at any of the locations visited.

SOURCES OF ASBESTOS

Asbestos is the name applied to a group of naturally fibrous minerals that are found in irregular veins scattered throughout rock masses in various parts of the world. Only a few of the deposits are of commercial importance.

There are several varieties of asbestos, differing considerably in composition and physical properties. The most important commercially is chrysotile, and its wide use is due to the fact that its fibers are strong and flexible. Other species of asbestos fall in the amphibole group, and the only ones used to any extent are anthopytllite, tremolite, amosite, and crocidolite.

In the United States asbestos has been found in the States of Alaska, Arizona, California, Georgia, Idaho, Maryland, Montana, North Carolina, Oregon, Vermont, Virginia, Washington, and Wyoming, but production has been negligible except in California, Vermont, Arizona, and North Carolina.

Most of the asbestos mined in the world is produced by companies that also fabricate finished asbestos products. They are strong, well organized concerns that maintain a tight control throughout all phases of the business, including mining, processing, manufacturing, and

marketing of asbestos and asbestos products. As an example, the largest producer in the world, operates asbestos mines in Canada and the United States, and manufactures asbestos products in more than forty five domestic and eight overseas plants. The products include all the important large volume items that contain asbestos.

MATERIAL FLOW
ASBESTOS

MATERIAL FLOW CHART - 1968

(Short Tons)

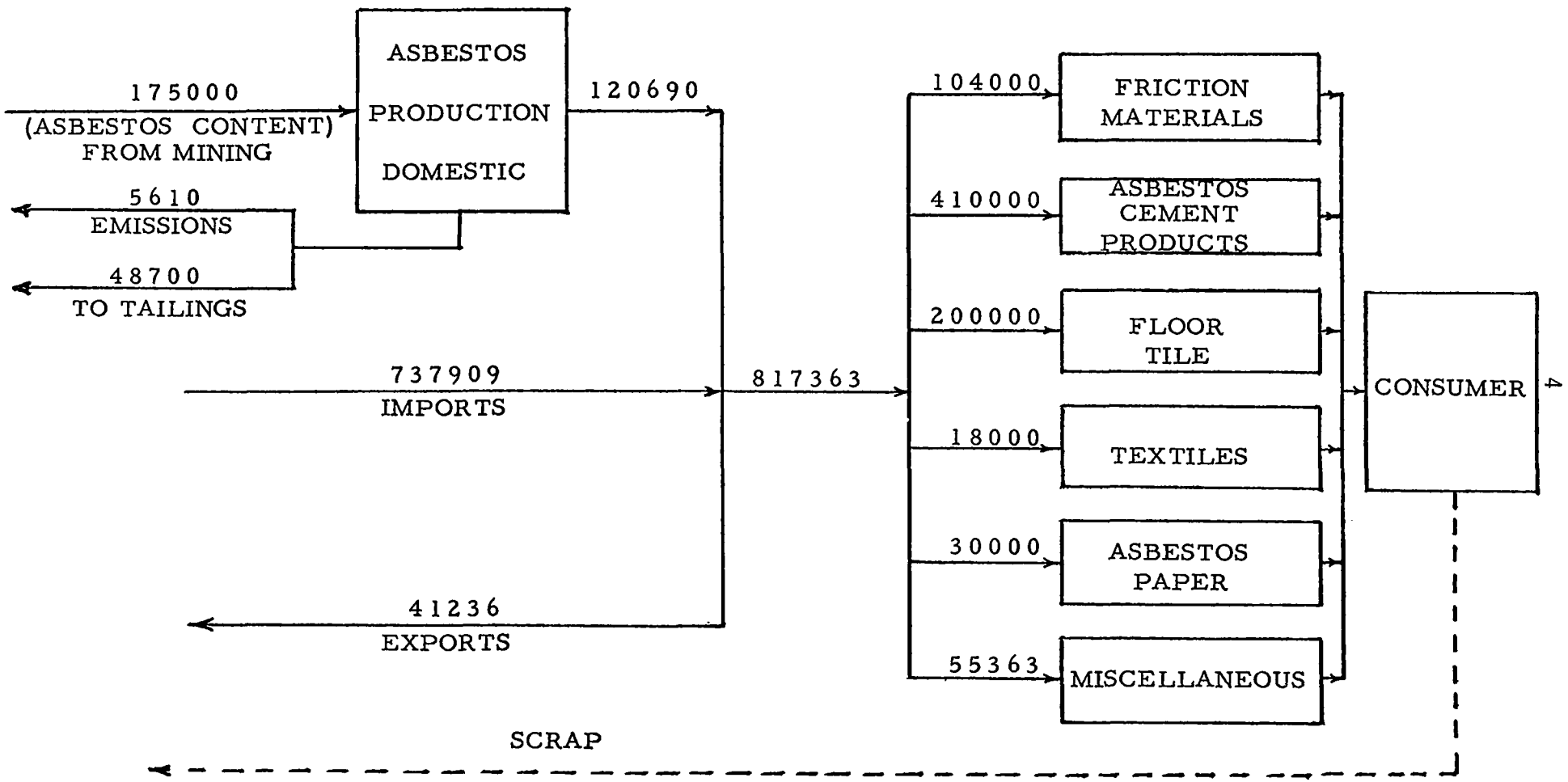

Figure V

MINING AND PROCESSING

There are eight asbestos mining companies in the United States that produce chrysotile fiber. Four of these mines are located in California, three in Arizona, and one in Vermont.

In Arizona the mining operations are all in the Salt River Valley north of Globe, and the mills are either at the mines or in Globe. The California asbestos mines and mills are in the counties of San Benito, Fresno, and Calaveras. The largest mine and mill in the United States is in Vermont near the Canadian border.

One company operating in Yancey county, North Carolina, produces a small amount of amphibole asbestos fiber.

Asbestos production in the United States during 1968 is reported as 120,690 short tons.[1] Mining companies are listed in Appendix A.

Asbestos Production in the United States

1 9 6 8

STATE	SHORT TONS
Arizona	1,390
California	75,592
North Carolina and Vermont	43,708

1- Bureau of Mines Minerals Yearbook - 1968

ASBESTOS IMPORTS

During 1968, asbestos imports were 737,909 short tons. Approximately 94 percent of the import total was from Canada and 5 percent was from the Republic of South Africa.[1]/

ASBESTOS EXPORTS

Asbestos exports, during 1968, were 41,236 short tons.[2]/

1-2- Bureau of Mines Minerals Yearbook - 1968

REPROCESSING

The apparent consumption of asbestos in the United States, during 1968, has been reported at 817,363 short tons.[1]

FRICTION MATERIALS

Asbestos is regarded as indispensable in most types of friction materials. It is used as the primary constituent in brake linings and clutch facings for motor vehicles, and other commercial and industrial equipment.

Brake linings are of two principal types. In the early days of the automobile, virtually all brakebands were of woven asbestos fabrics but now the molded type is used extensively. Molded linings consist of asbestos fibers bonded with an organic matrix. Metallic reinforcing is commonly added, and the shaped products are thoroughly cured. Chrysotile asbestos is required, ranging in fiber length from the very short grades to those just under spinning grades.

In the United States the use of asbestos in friction materials during 1968 was about 104,000 short tons.[2] Reprocessing plants producing friction materials are listed in Appendix A.

1- Bureau of Mines Minerals Yearbook - 1968
2- Estimate based on reports from reprocessing companies and data from the 1967 Census of Manufacturers.

ASBESTOS CEMENT PRODUCTS

Asbestos building materials, such as roofing shingles, siding, flat sheets, corrugated sheets, and wallboard consist of portland cement and approximately 15 percent shingle grade asbestos. The mix for asbestos cement pipe may contain as much as 20 percent.

In the United States the use of asbestos in asbestos cement products, during 1968, is estimated at 410,000 short tons.[1]/ Reprocessing companies producing asbestos cement products are listed in Appendix A.

FLOOR TILE

Asbestos is used extensively in asphalt floor tile, and in vinyl asbestos floor tile as a filler and binder. The total amount of asbestos used for this purpose has not changed much during the past few years, but less is used now in asphalt products and more in the vinyl asbestos flooring.

The use of asbestos in floor tile during 1968, is estimated at 200,000 short tons.[2]/ Reprocessing companies using asbestos in floor tile are listed in Appendix A.

1- Estimate based on data from 1967 Census of Manufacturers and Bureau of Mines Minerals Yearbook - 1968.
2- Bureau of Mines Minerals Yearbook - 1968.

TEXTILES

Long fiber or spinning grade asbestos is required for textiles and the process involved in manufacturing asbestos fabrics is much the same as that employed in spinning or weaving cotton and wool. In fact, a small amount of cotton or some other organic fiber is normally used along with the asbestos. The asbestos content usually ranges from 75 to 99 percent.

Yarns are made in various sizes and used for many purposes. Yarn used for brake linings is usually reinforced with fine copper, brass or lead wire and woven into strips. Yarn for electrical insulating tape should contain not more than 7 percent carbon, and not more than 14 percent cotton. Yarn for cloth varies depending on the end use of the material. Asbestos cloth is used for safety clothes, gloves, gaskets, insulating blankets, and numerous other purposes.

In the United States, asbestos used in textiles during 1968 totaled about 18,000 short tons.

ASBESTOS PAPER

Asbestos paper is used for many purposes such as; roofing felt, a paper or tape for covering hot ductwork, in the manufacture of air-cell pipe covering. Millboard is used in the manufacture of mill-

board gaskets.

It is estimated that the quantity of asbestos used in paper in the United States during 1968 totaled 30,000 short tons.

MISCELLANEOUS

In addition to the above mentioned uses, asbestos is used in filters, insulating materials, auto undercoating, roofing compound, boiler cement, plastics, rubber, wall joint tape, wall joint cement, gas mask filters, welding rod coating, fireproofing materials, compounded packings, fire walls, oil well drilling mud, etc.

About 15,000 to 17,000 tons of asbestos is used each year in insulation materials that are for insulating pipes, ducts, boilers, and other hot equipment. The asbestos content of the insulation is about 15 percent.

About 3,000 tons of asbestos is used each year in material that is sprayed-on steel columns and other structures for fire protection.

The miscellaneous uses of asbestos, during 1968, are estimated at 55,363 short tons.

E M I S S I O N S

MAP OF EMISSION REGIONS

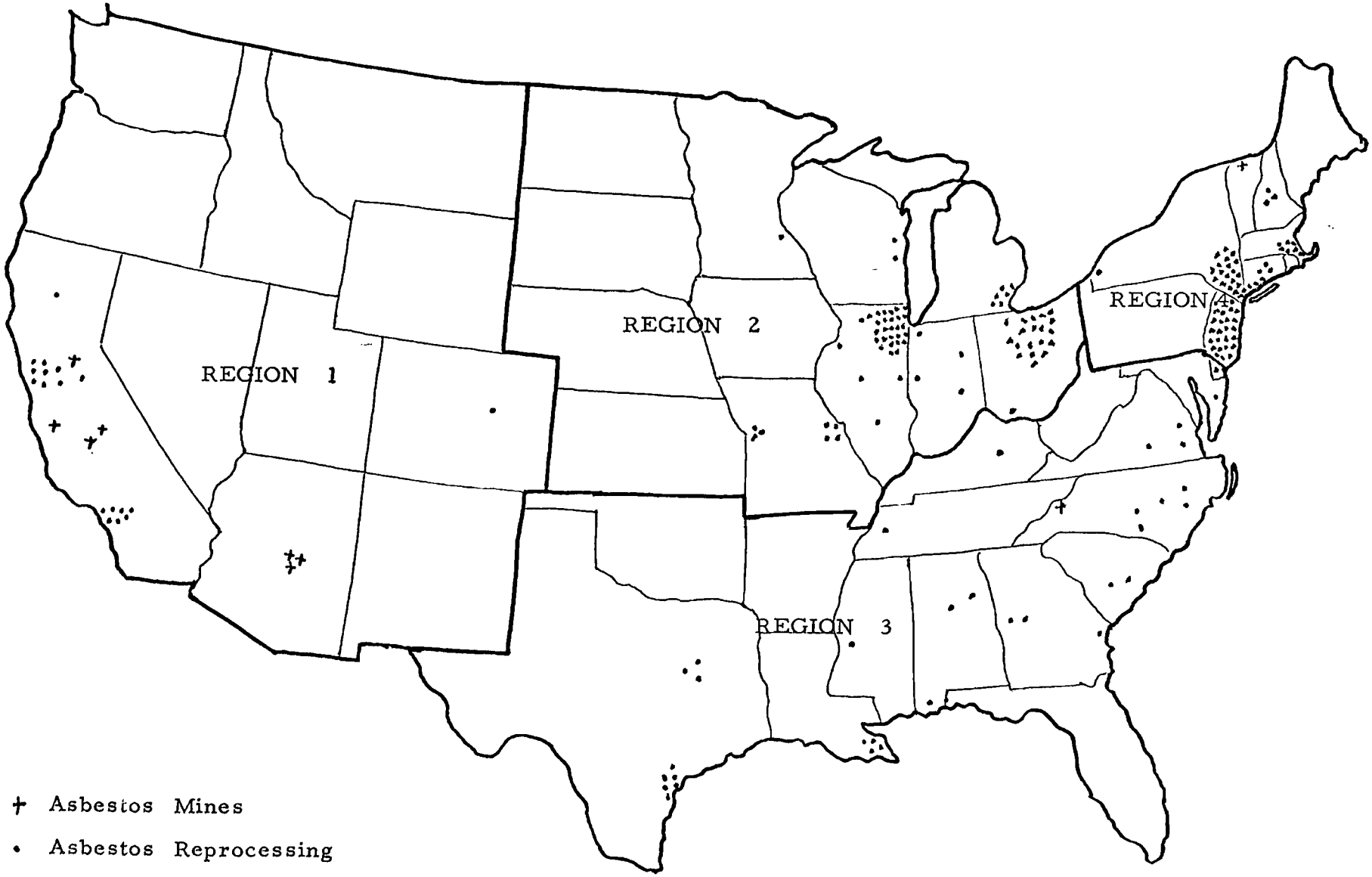

Figure VI

ASBESTOS EMISSIONS

1 9 6 8

SOURCE CATEGORY	SOURCE GROUP		SHORT TONS
MINING AND OTHER BASIC PROCESSING	Mining and Milling		5,610
REPROCESSING			678
	Friction Materials	312	
	Asbestos Cement Products	205	
	Textiles	18	
	Paper	15	
	Floor Tile	100	
	Miscellaneous	28	
CONSUMPTIVE USES			291
	Construction	61	
	Brake Linings	190	
	Steel Fireproofing	15	
	Insulating Cement	25	
INCINERATION OR OTHER DISPOSAL			NA
	TOTAL		6,579

NA - Data not available.

EMISSIONS BY REGION

	PLANTS	SHORT TONS
Region No. 1	7	3570
Region No. 2	-	-
Region No. 3	1	20
Region No. 4	1	2020

Regional distribution includes the source groups - Mining and Milling (representing 85 percent of total emissions)

Undistributed 15 percent 969

ASBESTOS EMISSIONS FACTORS

MINING AND OTHER PROCESSING	C	93 lb/ton of asbestos produced
REPROCESSING		
Friction Materials	C	6 lb/ton of asbestos processed
Asbestos Cement Products	C	1 lb/ton of asbestos processed
Textiles	C	2 lb/ton of asbestos processed
Paper	C	1 lb/ton of asbestos processed
Floor Tile	C	1 lb/ton of asbestos processed
CONSUMPTIVE USES		
Brake Linings	NC	10 lb/ton of asbestos processed
Steel Fireproofing	NC	10 lb/ton of asbestos applied
Insulating Cement	C	25 lb/ton of asbestos applied

Asbestos emissions factors are based on particulate control indicated as follows:

Mining and Other Processing	- Eighty percent.
Friction Materials	- Ninety five percent.
Asbestos Cement Products	- Seventy five percent.
Textiles	- Ninety five percent.
Paper	- Seventy five percent.
Floor Tile	- Seventy five percent.
Insulating Cement	- Eighty nine percent.

C - Controlled
NC - Not Controlled

PARTICLE SIZE OF EMISSIONS

Field sampling and lab testing were not a part of this study, and throughout this report there are numerous statements to the effect that information concerning the particle size of asbestos emissions is not available from mining processing, and reprocessing companies. All these companies stated they were not aware of any accurate method for testing asbestos emissions.

Even though there is a lack of data concerning the particle size of asbestos emissions, there is considerable information available regarding the dimensions of asbestos fibers. The diameter of chrysotile fiber ranges from about 0.018 to 0.03 microns, and the length varies from a fraction of a micron to 30,000 microns and longer.

It is reasonable to assume the size of some asbestos emission particles would be about the same as that of a single fiber, (0.018 to 0.03 micron) and others may consist of a cluster of fibers several microns in diameter and more than a thousand microns in length.

The dust observed in some of the mine offices appeared to consist of very fine particles, possibly ranging in size from 1 to 40 microns. The particle size of most emissions from bag filters at reprocessing facilities is probably in the range of 1 to 10 microns.

MINING
and
OTHER BASIC PROCESSING

In the United States most of the asbestos mining operations are of the open-pit type and the milling facilities are located reasonably close to the mines. At some locations the rock is easily removed without blasting, but at others, it is necessary to blast in order to loosen the material. From the standpoint of atmospheric emissions, it is unfortunate that blasting is necessary.

At many locations the rock containing the asbestos is moved from the mine to a storage pile near the mill where it remains until it is again moved into the mill for processing. During the loading, unloading, and moving operations, there are emissions, and the magnitude of those emissions depends on the atmospheric conditions.

Chrysotile asbestos is a fibrous form of serpentine, and is usually associated with massive fractured serpentine. The concentration process is unusual in that it involves the separation of a fibrous mineral from a massive form of the same mineral. Neither chemical composition, nor specific gravity can be used as a basis for separation; however, mechanical separation is possible. Due to its fibrous structure, it can be divided into filaments that are amenable

to separation by air suction and screening.

Since the long fibers of chrysotile asbestos are worth several times as much as the short ones, it is important to accomplish separation of fiber from rock with a minimum of fiber breakage. Asbestos milling consists essentially of course crushing, drying, and recrushing in stages, each step being followed by screening, and air separation of the fiber from rock.

In Arizona the mining is underground and the fiber is found in veins that occur in bands from a few inches to a few feet in thickness. The fiber is mined in drifts and stopes, using modified room-and-pillar methods, and mining costs are relatively high. Since mining is underground, the atmospheric emissions are considered as negligible.

In Vermont, the fiber-bearing rock is removed from an open pit, which is worked on three benches, each 125 feet high. About 50,000 tons of rock is broken with each multiple blast.[1]

Operations in California are well organized and efforts are made to control emissions, but the very nature of the operation makes emission control difficult. During one field trip, it was observed that trucks transporting rock were covered with tarpaulins; however, the tarpaulins were loose and the dust was blowing. A fine dry dust was noticed at

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1- Bowles, Oliver; Asbestos - A Materials Survey; Bureau of Mines Information Circular 7880 - 1959.

all locations - inside and outside. A fine dust haze was observed at a distance of several miles from some of the mining and milling operations.

In general, emission control equipment is used to some extent at all milling facilities. At one location visited, mechanical type collectors were used, and the operator estimated a two percent fiber loss to the atmosphere, based on the total asbestos fiber processed. At the second location, there were four mechanical dust collectors, and one was equipped with a bag filter. At the third location all of the cyclone collectors were equipped with bag filters, but there was a light fog of asbestos inside the mill building. At the fourth mill, there were bag filters, but there was no collector on the dryer. There was a light haze over the plant due to rock unloading. At the fifth mill, bag filters were used except for the cyclone collector on the dryer. At the sixth mill, which was not in operation at the time the field trip was made, there was a baghouse, but dust was everywhere - in the office, and in the conference room. At the seventh mill, no visitors were allowed beyond the office without permission from the home office in New York.

Without exception, there was no data regarding emissions. There were no records or tests showing the asbestos content or the asbestos particle size of the emissions.

Even though emissions data was not available, an emissions factor of 93 pounds per ton of asbestos produced has been estimated for mining and milling operations. This factor is based on the type of emissions control equipment used and its collection efficiency.

ASBESTOS EMISSIONS FACTORS FOR MINING AND MILLING*
(pounds per ton of asbestos produced)

	Uncontrolled	Cyclone	Baghouse	Emission Factor
Mining	X			3
Loading	X			2
Hauling	X			2
Unloading	X			2
Crushing & Drying		X		10
Milling		X	X	64
Tailings	X			10
				93

* Based on baghouse efficiency @ 99.5% and cyclone efficiency @ 80%.

For the year 1968, the asbestos emissions to the atmosphere from sources of mining and milling are estimated at 5,610 short tons, based on an average emissions factor of 93 pounds per ton of asbestos produced.

REPROCESSING

An outstanding characteristic of the asbestos industry is that a very large proportion of the fiber is mined, imported, processed, and reprocessed by a relatively few companies. Very little of the finished product is sold to the consumer trade.

The original use of asbestos was based on its heat resistance properties, but the current use is more often as a binder; such as in asbestos cement products.

The asbestos fibers are usually sold in 100 pound bags which are paper bags or jute bags which sometimes have a plastic liner. The disposal of these bags seems to present a problem to the industry. A few are able to use the paper bags in the product being produced, but many more are still seeking a satisfactory solution.

FRICTION MATERIALS

One of the largest uses of the friction material is in brake linings of the molded type. The molded linings, consisting of asbestos fibers bonded with an organic matrix, contain approximately fifty percent asbestos. As a part of the manufacturing process, the linings must be shaped and finished by grinding after they are formed. This

creates a substantial loss of asbestos, as much as thirty percent. With such a grinding procedure an adequate exhaust and collection system is essential.

A large manufacturer of brake linings reported 4000 tons of asbestos collected in bag filters at one plant during 1968 and described his collection system. He estimated overall atmospheric emissions of asbestos to be 0.25 to 0.50 percent, based on the efficiency of his collection equipment. Other manufacturers provided some information regarding the type of collection equipment in operation, but not data or estimates of asbestos emissions.

On the basis of information obtained an emissions factor of 6 pounds per ton of asbestos processed is estimated, and asbestos emissions to the atmosphere during 1968 are 312 short tons.

ASBESTOS CEMENT PRODUCTS

Asbestos cement products contain 15 to 20 percent asbestos, cement, and minor amounts of other ingredients.

In one method of pipe manufacture, a slurry of asbestos, cement, and water is collected on a felt-covered belt and the water is removed by suction. The sheet is then wound on a rotating metal cylinder to form the pipe. After the pipe wall is built to the desired thickness, the pipe is steam cured.

Asbestos shingles and siding products, manufactured by the dry process, have a dry mix which is spread evenly on a conveyor belt before water is added. When produced by the wet method, the water is added before the forming is initiated.

From the standpoint of air pollution during manufacture of asbestos cement products, the principal emissions occur when unloading the asbestos and while handling it in a dry condition.

Data regarding the magnitude and nature of asbestos emissions to the atmosphere was not available at any asbestos cement plant that was visited during this study; therefore, an emissions factor based on visual inspection is estimated as 1 pound per ton of asbestos processed.

Asbestos emissions to the atmosphere due to the manufacture of asbestos cement products, during 1968, are estimated at 205 short tons, based on an average emissions factor of one pound per ton of asbestos processed.

TEXTILES

During the manufacture of most asbestos textiles, a small amount of cotton or some other suitable organic fiber is mixed with the asbestos to help bind the asbestos fibers together during the spinning process. After all the fibers are thoroughly mixed, they are combed into a parallel position as they pass a succession of carding rolls. The loose blanket that has emerged from carding is separated into rovings and spun into yarn.

The spinning of the yarns and the subsequent weaving of the fabrics accumulates a considerable amount of lint and dust. To control this accumulation and cleanse the air inside the factory, it is the usual practice to exhaust the air from the building through a bag filter, and sometimes return the air from the filter to the factory. In asbestos textile mills, the amount of asbestos collected in bag filters is about 8 to 10 percent of the asbestos processed.

The following seems to be typical of asbestos textile manufacturing plants: At one plant where asbestos cloth, rope, tape, etc. is manufactured the air in the building is filtered through bag filters and returned to the factory. During 1968, 8 1/2 percent of the asbestos used was collected in the bag filters. Based on this in-

formation, an emissions factor is estimated at 2 pounds per ton of asbestos processed.

Asbestos emissions to the atmosphere from textile mills during 1968 are estimated at 18 short tons.

ASBESTOS PAPER

The methods used to make asbestos paper are similar to those employed in the manufacture of paper from wood pulp. Asbestos of paper-stock grade, sodium silicate, size, and starch are mixed with water to make a thin slurry. The material is conveyed to a paper machine, and as the sheet is formed, it passes between rollers and through driers to remove the water and dry the paper.

If a two-ply paper is desired, one side of a sheet is coated with sodium silicate, and the two sheets are run together over several hot rolls. Crimped paper is made by passing the sheets over corrugated rolls.

During the manufacture of asbestos paper and asbestos paper products, emissions to the atmosphere occur at the beginning of the process when the asbestos fiber is dry, and also again after the paper is formed. The magnitude of the emissions due to dusting depends, to a large extent, on the number of times the paper is handled as the products are manufactured.

Since manufacturer's data was not available regarding asbestos emissions during the manufacture of paper, the emissions factor

was estimated at one pound per ton of asbestos processed.

Asbestos emissions to the atmosphere due to the manufacture of asbestos paper during 1968 are estimated at 15 short tons, based on an emissions factor of one pound per ton of asbestos processed.

MISCELLANEOUS

A light fluffy form of magnesium carbonate combined with asbestos fiber makes an effective heat insulation for steam pipes. Such products are commonly referred to as "85 percent magnesia", and they are manufactured by mixing magnesium carbonate and asbestos in water, collecting the solids on a filter press and casting the mix in the form of pipe insulation.

The manufacture of molded articles for electrical fittings and household appliances is similar to many other manufacturing procedures regarding the manner in which asbestos fiber is handled. Asbestos is mixed with other ingredients, ground, compressed in molds, baked and polished. The asbestos becomes "locked-in" during the process and thereafter presents a minimum hazard with respect to air pollution.

Asbestos emissions to the atmosphere, during 1968, due to the manufacture of miscellaneous products that contain asbestos are estimated at 28 short tons, based on an emissions factor of 1 pound per ton of asbestos processed.

CONSUMPTIVE USES

When asbestos material is used, most is applied by the building trades or some specialty group. In these cases most of the emissions to the atmosphere occur during the cutting, handling, or spraying of the asbestos products.

There are exceptions, one of the outstanding being the replacement of motor vehicle brake linings.

The abrasion of brake and clutch facings during use may be another source of atmospheric emissions of asbestos.

Rock from asbestos mines, used as a road surfacing agent, would also result in an emission to the atmosphere from use.

Road Surfacing

There have been several reports that tailings from asbestos milling operations are used for surfacing roads. Sometimes the rock is mixed with oil or asphalt, and at other times, it is used as it comes from the mill.

At one location visited during a field trip, it was reported that 150,000 tons of mill tailings, containing about 2 tons of asbestos

fiber, were sold to a contractor during 1968 for use on roads. It is reported that an appreciable amount is used in Vermont for roads.[1] This could not be confirmed, since permission to visit the mine and mill was denied.

Construction

Workmen in all trades in the construction industry come in contact with asbestos. Heating ducts are often insulated with asbestos, and steam piping is nearly always covered with a material containing asbestos. Electricians strip asbestos insulation from wires, and the carpenter saws asbestos siding, wallboard, and shingles. As a result, there is asbestos released to the air around the construction sites.

Asbestos emissions to the atmosphere at construction sites are estimated at 61 short tons for 1968.

Brake Linings

Motor vehicle travel during 1968 totaled one trillion miles, and replacement brake linings were required for about 25 to 30 million vehicles. It is the usual practice, when installing new brake linings,

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1- May-Timothy C.; Asbestos; Mineral Facts and Problems; Bureau of Mines Bulletin 630 - 1965

to fit the linings to the drums by grinding, and the amount of grinding required varies depending on the condition of the brake drum.

Data concerning motor vehicle brake linings:

Vehicle miles during 1968	1,010,000,000,000
Mileage life of brake linings	27,500
Brake lining sets on new vehicles	10,718,000
Pounds of asbestos per set of brake linings	3
Assumed loss to atmosphere during grinding and fitting - percent	0.5

Based on the above, the emissions factor is 10 pounds per ton of asbestos processed, and the asbestos emissions to the atmosphere during 1968 were 190 tons.

Steel Fireproofing

Several spray-on materials that contain asbestos are used extensively on steel columns and other structures as a fire protection measure. The application of such materials is often required by code. Even though the building frame may be covered by a temporary enclosure when the material is sprayed, the workmen are exposed to an atmosphere that is virtually saturated with asbestos fiber.

Asbestos emissions to the atmosphere, due to the use of spray-on fireproofing during 1968, are estimated at 15 short tons,

based on an emissions factor of 10 pounds per ton of asbestos applied.

Motor Vehicle Use

It is obvious that there are substantial particulate emissions from the wear of motor vehicle brake linings and clutch facings. This has been reported as a primary source of asbestos emissions to the atmosphere; however, there are conflicting reports indicating that the asbestos fiber has been destroyed by the heat of friction.

In this report the estimate of emissions does not include an amount for the wear of motor vehicle brake linings and clutch facings.

Insulating Cement

Insulating cement that contains asbestos is used extensively in all types of boilers. It is used for pointing up joints and cracks in stack and breeching linings, and for surfacing block insulation that is installed inside breechings, ducts and economizers. During the boiler operation, as the flue gas passes through the boiler some of the insulating cement is worn away and carried along through the dust collector, up the stack, and into the atmosphere.

Based on the following assumptions, an emissions factor of 33

pounds per ton of asbestos applied is calculated for the use of insulating cement.

1 - Fifteen percent of the insulating cement worn away during use,

2 - Dust collector efficiency - 89 percent (average)

Asbestos emissions to the atmosphere during 1968 due to the use of insulating cement are estimated at 25 short tons.

INCINERATION OR OTHER DISPOSAL

The recovery of scrap is an important factor in some industries, but asbestos, once used, is rarely recovered for reuse. In most products, asbestos is combined with other materials in such a manner that it is difficult to separate into a usable form. Most of the discarded products that contain asbestos become part of the solid waste.

The greatest percentage of the asbestos is used in building materials; therefore, the debris from the demolition of buildings, and from new construction, contains most of the asbestos scrap.

In the process of destroying a building, some of the asbestos fibers would be released; and if the asbestos fiber is not destroyed by burning, there would be some asbestos released by incineration.

APPENDIX A

ASBESTOS MINES IN THE UNITED STATES

ARIZONA	LOCATION
Asbestos Manufacturing Company	Gila County
Jaquays Mining Corporation	Gila County
Metate Asbestos Corporation	Gila County
CALIFORNIA	
Atlas Minerals Corporation	Fresno County
Coalinga Asbestos Company (1)	Fresno County
Pacific Asbestos Corporation (2)	Calaveras County
Union Carbide Corporation	San Benito County
NORTH CAROLINA	
Powhatan Mining Company	Yancey County
VERMONT	
GAF Corporation	Orleans County

(1) - Owned by Johns-Manville Corporation

(2) - Acquired by H. K. Porter Company, Inc. during 1968.

REPROCESSING PLANTS PRODUCING ASBESTOS FRICTION MATERIALS

CALIFORNIA	LOCATION
H. Krasne Manufacturing Company	Los Angeles
Silver Line Brake Lining Corporation	Los Angeles
Lasco Brake Products Corporation, Ltd.	Oakland
CONNECTICUT	
H. K. Porter Company, Inc.	Middletown
Raybestos-Manhattan, Inc.	Stratford
ILLINOIS	
Gatke Corporation	Chicago
Grizzly Brake Division of Mar Pro Inc.	Chicago
The L. S. Miley Company	Chicago
Johns-Manville Corporation	Waukegan
INDIANA	
Raybestos-Manhattan, Inc.	Crawfordsville
H. K. Porter Company, Inc.	Huntington
World Bestos Company (sub. of Firestone Tire & Rubber Co.)	New Castle
KENTUCKY	
H. K. Porter Company, Inc.	Richmond
MASSACHUSETTS	
Auto Friction	Lawrence
MICHIGAN	
American Brakeblock - Division Ambes Corp.	Birmingham
American Brake Shoe Company	Troy

NEW JERSEY

Johns-Manville Corporation	Manville
Reddaway Manufacturing Company, Inc.	Newark
Raybestos-Manhattan, Inc.	Passaic
H. K. Porter Company, Inc.	Trenton

NEW YORK

Bendix Corporation	Troy

NORTH CAROLINA

Southern Friction Materials Company	Charlotte

OHIO

American Brake Shoe	Cleveland
General Motors Corporation	Dayton
Maremont Corporation	Paulding

PENNSYLVANIA

Raybestos-Manhattan, Inc.	Manheim
H. K. Porter Company, Inc.	Pittsburgh

TEXAS

Standco Brake Lining Company	Houston

TENNESSEE

Bendix Corporation	Cleveland

VIRGINIA

American Brake Shoe	Winchester

(Thomas Register, Dec., 1968 Ed., Fortune-1966 Plant & Product Directory of the 1000 Largest U.S. Industrial Corporations; U.S. Department of Commerce.)

REPROCESSING PLANTS PRODUCING ASBESTOS CEMENT PRODUCTS

ALABAMA	LOCATION
U. S. Cast Iron Pipe Company	Anniston
GAF Corporation	Mobile
Cement Asbestos Products Company	Woodward
CALIFORNIA	
Southern Pipe & Casing Company	Azuza
Johns-Manville Corporation	Long Beach
Johns-Manville Corporation	Pittsburgh
Certain-Teed Products Corporation	Riverside
Certain-Teed Products Corporation	Santa Clara
Johns-Manville Corporation	Stockton
CONNECTICUT	
Tile Roofing Company	Stratford
GEORGIA	
Uniroyal, Inc.	Hogansville
GAF Corporation	Port Wentworth
ILLINOIS	
Acme Asbestos Covering & Flooring Company	Chicago
Asbestos & Magnesia Materials Company	Chicago
Flintkote Company	Chicago
Western Slate Company	Elmhurst
Fel-Pro, Inc.	Skokie
Johns-Manville Corporation	Waukegan
INDIANA	
U. S. Gypsum Company	East Chicago

LOUISIANA

Johns-Manville Corporation	Marraro
National Gypsum Company	New Orleans

MASSACHUSETTS

Johns-Manville Corporation	No. Billerica

MICHIGAN

American Asbestos Products Company	Detroit

MINNESOTA

Mac Arthur Company	St. Paul

MISSOURI

Certain-Teed Products Corporation	St. Louis
GAF Corporation	St. Louis
National Gypsum Company	St. Louis

NEW HAMPSHIRE

Johns-Manville Corporation	Nashua

NEW JERSEY

Johns-Manville Corporation	Manville
National Gypsum Company	Millington
Philip Carey Manufacturing Company	Perth Amboy
GAF Corporation	So. Bound Brook
U. S. Plywood-Champion Papers, Inc.	South River

NEW YORK

Asbeka Fabricators Corporation	Brooklyn
National Gypsum Company, Inc.	Buffalo
Flintkote Company	White Plains

NORTH CAROLINA

H. K. Porter Company, Inc.	Charlotte
Johns-Manville Corporation	Marshville

OHIO

Philip Carey Manufacturing Company	Cincinnati
Seagrave	Columbus
Flintkote Company	Ravenna

PENNSYLVANIA

Certain-Teed Products Corporation	Ambler
Nicolet Industries, Inc.	Ambler
Supradur Manufacturing Company (sub. of Seagrave)	Windgap

TEXAS

Johns-Manville Corporation	Dennison
Certain-Teed Products Corporation	Hillsboro
Philip Carey Manufacturing Company	Houston

WISCONSIN

Wisconsin Gasket & Manufacturing Company	Milwaukee

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REPROCESSING PLANTS USING ASBESTOS IN FLOOR TILE

CALIFORNIA	LOCATION
GAF Corporation	Long Beach
Armstrong Cork Company	South Gate
Flintkote Company	Vernon
ILLINOIS	
Flintkote Company	Chicago
GAF Corporation	Joliet
Armstrong Cork Company	Kankakee
Johns-Manville Corporation	Waukegan
LOUISIANA	
Johns-Manville Corporation	Marraro
Flintkote Company	New Orleans
MASACHUSETTS	
Flintkote Company	Watertown
MISSISSIPPI	
Armstrong Cork Company	Jackson
NEW JERSEY	
Congoleum-Nairn, Inc.	Kearny
Johns-Manville Corporation	Manville
American Builtrote Rubber Company, Inc.	Trenton
NEW YORK	
GAF Corporation	Vails Gate

OHIO

Johns-Manville Corporation	Chillicothe

PENNSYLVANIA

Armstrong Cork Company	Lancaster

TEXAS

GAF Corporation	Houston

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OTHER ASBESTOS REPROCESSING PLANTS

ALABAMA	LOCATION	CODE
GAF Corporation	Mobile	B
CALIFORNIA		
Hill Brothers Chemical Company	City of Industry	
Fibreboard Paper Products Corporation	Emeryville	C
Johns-Manville Corporation	Pittsburg	B C
Fibreboard Paper Products Corporation	Redwood City	B
Scott Labs, Inc.	Richmond	C
Sacomo Manufacturing Company	San Francisco	A B C
George Short Company	San Francisco	C
COLORADO		
The Verticel Company	Englewood	
CONNECTICUT		
Brosites Industries, Inc.	Greenwich	
Standard Washer & Material, Inc.	Manchester	C
Auburn Manufacturing Company	Middletown	C
DELAWARE		
Haveg Industries, Inc.	Wilmington	
GEORGIA		
Terri-Cord Mills	Roberta	
ILLINOIS		
Unarco Industries, Inc.	Bloomington	C
Accurate Felt & Gasket Manufacturing Co.	Chicago	C
Acme Asbestos Covering & Flooring Co.	Chicago	B

Asbestos & Magnesia Materials Company	Chicago	A B
Asbestos Textile Company	Chicago	A
Chambers Gasket & Manufacturing Company	Chicago	C
Colonial Kolonite Company	Chicago	
A. Daigger & Company	Chicago	C
Filpaco Industries, Inc.	Chicago	C
Geraghty Gasket & Manufacturing Company	Chicago	C
L. E. Harnisch & Company	Chicago	B C
John Herman Manufacturing Corporation	Chicago	A
Industrial Hermetic Materials, Inc.	Chicago	C
Kopel Filter Paper Company	Chicago	C
Sall Mountain Company	Chicago	C
Singer Safety Products, Inc.	Chicago	A
Grant Wilson, Inc.	Chicago	A B
United Gasket Corporation	Cicero	C
Industrial Gloves Company	Danville	A
GAF Corporation	Joliet	B
F. D. Farnam Company	Lyons	A B C
Luse-Stevenson Company	Melrose Park	C
Blackhawk Gasket Corporation	Rockford	C
Excelsior Leather Washer Mfg. Co.	Rockford	C
Nicolet Industries, Inc.	Union	
Johns-Manville Corporation	Waukegan	B C

LOUISIANA

Johns-Manville Corporation	New Orleans	B

MARYLAND

Congoleum-Nairn, Inc.	Cedarhurst	B

MASSACHUSETTS

Armstrong Cork Company	Braintree	C
Pepperell Braiding Company	East Pepperell	A
Barwood Manufacturing Corporation	Everett	C
Asbestos Textile Company, Inc.	No. Brookfield	A

MICHIGAN

Detroit Gasket & Manufacturing Company	Detroit	B
Great Lakes Filter Media Company	Detroit	C
Walker Manufacturing Company	Jackson	

MISSOURI

GAF Corporation	Kansas City	B
Standard Asbestos Mfg. & Insulating Co.	Kansas City	B C
General Gasket Corporation	St. Louis	C
Tallman-McCluskey Fabrics Company (sub. of H. K. Porter Co., Inc.)	St. Louis	A

NEW HAMPSHIRE

American Asbestos Textile Corporation	Meredith	A
Johns-Manville Corporation	Tilton	B C

NEW JERSEY

Howard Industries, Inc.	Berkley Heights	
Asbesto Corporation	Bloomfield	A
Kavon Filter Products Company	Cranford	C
Janos Asbestos Company	East Rutherford	A B C
GAF Corporation	Gloucester City	B
Columbia Filter Company	Hawthorne	C
Cellulo Company	Hoboken	C
Imperial Products Company	Hoboken	
Ladden Asbestos Corp. of New Jersey	Irvington	A B
Smyth Rubber & Packing Company	Jersey City	C
Smith & Kanzler Corporation	Linden	B C
Johns-Manville Corporation	Manville	B C
Flaherty-Kennedy Filter Fabrics	Maplewood	C
Asbestos Products Mfg. Corp.	Newark	C
Asbestospray Corporation	Newark	C
Johns-Manville Corporation	New Brunswick	C
Electrical Insulation Sales Company	North Bergen	C
Brassbestos Manufacturing Corporation	Patterson	
La Favorite Rubber Manufacturing Co.	Patterson	C
J. T. Baker Chemical Company	Phillipsburg	
Minerals & Insulation Company, Inc.	Rochelle Park	C
Baldwin-Ehret-Hill, Inc.	Trenton	C

NEW YORK

Atlantic Asbestos Corporation	Bronx	B C
Able-Val Canvas & Rope Mfg. Co.	Brooklyn	A
Acme Canvas & Rope Company	Brooklyn	A
Eureka Packing Company	Brooklyn	A
Smith Chemical & Color Company	Brooklyn	

U. S. Indestructible Gasket Company	Brooklyn	A C
Armstrong Cork Company	Fulton	B
National Filter Corporation	Mt. Vernon	C
Asbestos Ltd.	New York City	
Atlantic Asbestos Corporation	New York City	
Scientific Filter & Machinery Company	New York City	
Whittaker, Clark & Daniels, Inc.	New York City	
Pam Narrow Fabrics Corporation	Oceanside	A
Garlock, Inc.	Palmyra	A C
Gaddis Engineering Company	Port Washington	B C

NORTH CAROLINA

Carolina Asbestos Company	Davidson	A
Tar Heel Mica Company	Plumtree	

OHIO

G. P. Hall Company	Akron	
Johns-Manville Corporation	Avery	B
The Blemker Company	Cincinnati	
Cincinnati Gasket Packing & Mfg. Co.	Cincinnati	C
Russel Gasket Company	Cincinnati	C
Zimmerman Packing Company	Cincinnati	C
Asbestos Products Company	Cleveland	
Bodwell-Lemmon Company	Cleveland	
Foseco Inc.	Cleveland	C
Russell Gasket Company	Cleveland	C
Nicolet Industries, Inc.	Hamilton	
The Cellulo Company	Sandusky	C
Asbeka Fabricators Corporation	Willoughby	C

PENNSYLVANIA

Keasbey & Mattison Company	Ambler	A C
Nicolet Industries, Inc.	Ambler	C
GAF Corporation	Erie	A C
Debco Products	Herminie	B
Raybestos-Manhattan, Inc.	Manheim	A C
American Asbestos Textile Corporation	Norristown	A
Nicolet Industries, Inc.	Norristown	
Atlas Asbestos Company	North Wales	A
Greene Tweed & Company	North Wales	C
Aljay Manufacturing Company	Philadelphia	A

Anchor Packing Company	Philadelphia	C
Austen Hill Manufacturing Company	Philadelphia	
Burnswick Asbestos Company	Philadelphia	
Collins Packing Company	Philadelphia	C
Delaware Asbestos & Rubber Company	Philadelphia	
Manufactured Rubber Products Company	Philadelphia	
Mercer Rubber Company, Inc.	Philadelphia	A
Philadelphia Asbestos Corporation	Philadelphia	A C
George A. Rowley & Company, Inc.	Philadelphia	
Charles A. Wagner Company, Inc.	Philadelphia	
Armstrong Cork Company	Pittsburgh	C
Pittsburgh Corning Corporation	Pittsburgh	
Westinghouse Electric Corporation	Pittsburgh	C
Refractory and Insulation Corporation	Port Kennedy	C
Quaker Safety Products & Mfg. Co.	Quakerstown	
Carlisle Corporation	Ridgway	

SOUTH CAROLINA

H. K. Porter Company, Inc.	Bennettsville	A
Raybestos-Manhattan, Inc.	North Charleston	A C

TEXAS

GAF Corporation	Dallas	B
Johns-Manville Corporation	Fort Worth	B
Philip Carey Manufacturing Company	Houston	A
Standco Asbestos Textile Company	Houston	A C

VIRGINIA

Capitol Asbestos Fabricators Corporation	Alexandria
Forcee Manufacturing Corporation	Tappahannock

WISCONSIN

Ametek/Plymouth Plastics Division	Sheboygan

CODE - A - Textiles
B - Paper
C - Miscellaneous

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16. Abstracts

The inventory of atmospheric emissions has been prepared to provide reliable information regarding the nature, magnitude, and extent of the emissions of asbestos in the United States for the year 1968. Background information concerning the basic characteristics of the asbestos industry has been assembled and included. Process descriptions are given, but they are brief, and are limited to the areas that are closely related to existing or potential atmospheric losses of the pollutant. The asbestos emissions and emissions factors that are presented are based on information obtained from production companies that represent about fifty percent of the domestic production, and from reprocessing companies that handled about five percent of the asbestos consumed in 1968. The magnitude of the asbestos emissions from production facilities is subject to many variables, including atmospheric conditions, and is very difficult to estimate accurately. The emissions during mining, blasting, loading, hauling, and unloading are virtually uncontrolled, and visual inspection indicates that emissions are substantial

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Asbestos emissions
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