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Research and Development

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Status Assessment of Toxic Chemicals

Asbestos

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STATUS ASSESSMENT OF TOXIC CHEMICALS: ASBESTOS

by

S. R. Archer
T. R. Blackwood
Monsanto Research Corporation
Dayton, Ohio 45407

Contract No. 68-03-2550

Project Officer

David L. Becker
Industrial Pollution Control Division
Industrial Environmental Research Laboratory
Cincinnati, Ohio 45268

INDUSTRIAL ENVIRONMENTAL RESEARCH LABORATORY
OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
CINCINNATI, OHIO 45268

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FOREWORD

When energy and material resources are extracted, processed, converted, and used, the related pollutional impacts on our environment and even on our health often require that new and increasingly more efficient pollution control methods be used. The Industrial Environmental Research Laboratory - Cincinnati (IERL-Ci) assists in developing and demonstrating new and improved methodologies that will meet these needs both efficiently and economically.

This report contains a status assessment of the air emissions, water pollution, health effects, and environmental significance of phosphates. This study was conducted to provide a better understanding of the distribution and characteristics of this pollutant. Further information on this subject may be obtained from the Organic Chemicals and Products Branch, Industrial Pollution Control Division.

Status assessment reports are used by IERL-Ci to communicate the readily available information on selected substances to government, industry, and persons having specific needs and interests. These reports are based primarily on data from open literature sources, including government reports. They are indicative rather than exhaustive.

David G. Stephan
Director
Industrial Environmental Research Laboratory
Cincinnati

ABSTRACT

Asbestos, occurring naturally as a component of many soils, is a suspected carcinogen found in air, water, and food in various amounts in all parts of the United States.

In 1974, a total of 102,071 metric tons of asbestos were extracted from mines in California, Vermont, Arizona, and North Carolina. There are approximately 3,000 uses of asbestos in various industries, including construction, floor tiles, textiles, papers, plastics, friction products, and insulation. A total of 659 plants in these industries fabricate asbestos into a variety of products.

Asbestos enters the environment from so many sources that its presence may be regarded as ubiquitous, with only a small portion of the fibers arising from natural sources. Available data indicate that urban levels due to industrial sources, brake lining residues, and other sources, averaging 29 ng/m^3, are much greater than nonurban concentrations, which generally appear to be less than 1 ng/m^3. Mining and milling appear to result in the majority of atmospheric emissions, while asbestos fabrication in the construction industry results in the major asbestos water discharges. Maximum atmospheric asbestos concentrations have been calculated using industry data, and indications are that the maximum concentration of 6.2×10^{-9} g/m^3 will extend 1 km from an average operating asbestos plant (covering 2,060 km^2), and will fall off inversely with the square of further distances from the sources. Asbestos has been found in potable drinking water supplies ranging in concentration from 0.25×10^3 $fibers/m^3$ to 240×10^3 $fibers/m^3$, but no firm evidence is available regarding the hazard to man from waterborne asbestos.

Asbestosis (fibrosis of the lung) and pulmonary cancer are associated with mining and milling of asbestos and manufacturing asbestos products. Such emissions have been greatly reduced from previous levels, even though production and consumption of asbestos products has increased, due to enforcement of regulations under the Clean Air Act of 1970. Visible emissions from manufacturing operations have been prohibited, demolition operations are more strictly controlled, disposal of asbestos-contaminated wastes is regulated, and waste dump operations are specified to minimize dispersion of fibers into the environment.

The discovery of association of a unique tumor with very low-level exposure, or with casual contact with one form of asbestos, indicates that there may not be a safe level for this asbestos form. However, at this point there is no evidence of cancer risk to the general public from asbestos in air, water, beverages, or food.

Asbestos has been the subject of a variety of studies to determine standards for drinking water, air, workplace, and mine safety. An air standard has been promulgated for a number of major commercial sources of asbestos fibers. Effluent guidelines have been promulgated under the Federal Water Pollution Control Act which, together with the National Pollutant Discharge Emission System (NPDES) permit program, should reduce asbestos discharges.

A number of studies have been conducted involving the environmental consequences of the production and use of asbestos fibers and the incidental release as a result of other industrial processes which use asbestos as a feedstock or which contain it as an impurity. A significant amount of information has been collected on the use of asbestos in a wide range of industrial and household products. Environmental assessments have been and are being conducted for those industries which use significant amounts of asbestos. These include analyses of production processes, waste streams and control technologies. Research has been completed which documents the actual mass and fractional efficiency of baghouses, the predominately used control device. Research is continuing on the optimum use and maintenance of control devices to control asbestos emissions. More definite information concerning emission sources, environmental behavior and persistence, and health effects of long-term low-level exposure of airborne and waterborne asbestos is needed.

This report was submitted in partial fulfillment of Contract 68-03-2550 by Monsanto Research Corporation under the sponsorship of the U.S. Environmental Protection Agency. This report covers the period November 1, 1977 to December 31, 1977. The work was completed as of January 20, 1978.

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CONVERSION FACTORS AND METRIC PREFIXES[a]

CONVERSION FACTORS

To convert from	to	Multiply by
Degree Celsius (°C)	Degree Fahrenheit	$t^\circ_F = 1.8\ t^\circ_C + 32$
Joule (J)	British thermal unit	9.479×10^{-4}
Kelvin (K)	Degree Celsius	$t^\circ_C = t^\circ_K - 273.15$
Kilogram (kg)	Pound-mass (pound-mass avoirdupois)	2.204
Kilometer^2 (km^2)	Mile^2	3.860×10^{-1}
Meter (m)	Foot	3.281
Meter^2 (m^2)	Foot^2	1.076×10^{1}
Meter^3 (m^3)	Foot^3	3.531×10^{1}
Meter^3 (m^3)	Gallon (U.S. liquid)	2.642×10^{2}
Metric ton	Pound-mass	2.205×10^{3}
Siemens (S)	Mho	1.000

METRIC PREFIXES

Prefix	Symbol	Multiplication factor	Example
Kilo	k	10^3	1 kg = 1×10^3 grams
Centi	c	10^{-2}	1 cm = 1×10^{-2} meter
Micro	μ	10^{-6}	1 μm = 1×10^{-6} meter
Nano	n	10^{-9}	1 ng = 1×10^{-9} gram

[a] Standard for Metric Practice. ANSI/ASTM Designation: E 380-76$^{\varepsilon}$, IEEE Std 268-1976, American Society for Testing and Materials, Philadelphia, Pennsylvania, February 1976. 37 pp.

ACKNOWLEDGEMENT

This report was assembled for EPA by Monsanto Research Corporation, Dayton, OH. Mr. D. L. Becker served as EPA Project Officer, and Dr. C. E. Frank, EPA Consultant, was principal advisor and reviewer.

SECTION 1

INTRODUCTION

Asbestos, a naturally occurring component of many soils, is a suspected human carcinogen found in air, water, and food in varying amounts in all parts of the United States. Besides the natural release to the environment from wind and water erosion of asbestos-bearing formations, there are several types of man-made emissions, including those from mining and milling asbestos ores, consumptive use to manufacture asbestos products, wear or consumption of asbestos-containing products, and release of asbestos incidental to other industrial or commercial processes. Exposure to asbestos fibers may occur throughout urban environments, and asbestos fibers have been found in a number of drinking water supplies; thus there is concern about adverse health effects to the general population.

There is a need to define the various sources from which asbestos may enter the environment, to establish consequent health and environmental effects, and to examine possible control strategies and present regulatory actions. This report provides a brief overview describing these items with emphasis on asbestos sources and their environmental significance.

SECTION 2

SUMMARY

Asbestos is the name applied to a number of fibrous mineral silicates found naturally in irregular veins scattered throughout rock masses in various parts of the world.

Total 1974 U.S. asbestos output was 102,071 metric tons[a] from mines located in four states: California, Vermont, Arizona, and North Carolina. Asbestos is often mined by trenching or open-pit methods, followed by underground mining by tunneling or block-caving methods. Milling practice, essentially a dry screening operation, consists of multiple stages of crushing, screening, aspirating the fiber from the rock, sifting, recleaning the fiber, and grading.

There are approximately 3,000 uses of asbestos in various industries. Its greatest use is in the manufacture of asbestos cement products; its second largest use is in asphalt and vinyl floor tiles. Other industries using asbestos include textiles, electrical equipment, papers, plastics, felts, and friction materials.

Asbestos enters the environment from so many sources that its presence may be regarded as ubiquitous. Table 1 presents available information concerning emission sources, emission quantities, population exposed, pollution control technology, and regulatory agencies and actions.

Available data indicate that urban levels of asbestos in air, averaging 29 ng/m^3, are much greater than nonurban concentrations, averaging less than 1 ng/m^3, due to industrial emission sources, brake lining residues, and other sources such as building construction and demolition. Recent evidence indicates that asbestos is leached from asbestos-cement pipes in municipal water systems. In 1975, asbestiform fibers were found in 10 widely separated potable water supplies, ranging in concentration from 0.25×10^3 fibers/m^3 to 240×10^3 fibers/m^3.

The association of impaired human health with industrial exposure to asbestos is well known. Asbestosis (fibrosis of the lung) and

[a] 1 metric ton = 10^6 grams; conversion factors and metric system prefixes are presented in the prefatory pages of this report.

TABLE 1. ASBESTOS

Emission source	Extent of problem: Disposal quantity, metric tons/yr, 1972: Air	Water	Land[a]	Population density, persons/km^2	Control method	Regulatory agency or action
Production:						
Mining	597	–[b]	53,288	–[b]	Fabric filters during drilling.	Drinking water standard - National Academy of Sciences study of health effects of asbestos in drinking water.
Milling	1,194	48	5,045	–[b]	Cyclones, bag collectors, and ducts for dust control in crushing operation Cyclones, possibly followed by baghouses used on dryers All conveyors generally covered, low velocity hoods in other areas.	Hazardous air pollutant standard - Iron ore beneficiation plants being studied to determine possible coverage of current Hazardous Air Pollutant Standards.
Fabrication:					Fabric filters (baghouses)	
Construction	153	246	1,536	1,720		
Felts and paper	53	42	527	1,687		
Floor tile	38	4	385	2,960		Workplace standard - Proposed downward revision of workplace exposure limit.
Friction products	210	21	350	2,507		
Gaskets and packing	14	2	140	–[c]		
Insulation	18	4	89	–[c]		Workplace studies - Brake lining and clutch rebuilding industries being studied to determine best means of worker protection.
Textiles	7	1	35	2,203		
Other	54	5	535	2,300		
Consumption:						
Construction	54	–[b]	6,804	–[b]		Mine safety standard - Possible revision of mine safety standard for asbestos.
Felts and paper	–[b]	–[b]	2,631	–[b]		
Floor tile	–[b]	–[b]	11,521	–[b]		
Friction products	–[b]	–[b]	69,382	–[b]		
Gaskets and packing	–[b]	28	27,779	–[b]		Priority pollutant - asbestos is listed as a priority pollutant under the Federal Water Pollutant Control Act.
Insulation	37	–[b]	443	–[b]		
Textiles	–[b]	–[b]	6,963	–[b]		
Other	–[b]	–[b]	53,115	–[b]		

[a] Includes residual solid waste.

[b] Not available.

[c] Combined population density for gaskets, packing, and insulation equals 2,800 persons/km^2.

pulmonary cancer are associated with mining and milling of asbestos and manufacturing asbestos products. The discovery of association of a unique tumor with very low-level exposure, or with casual contact with one form of asbestos, indicates that there may not be a safe level for this asbestos form. However, at this point there is no evidence of cancer risk to the general public from asbestos in air, water, beverages, or food.

Fabric filters (baghouses) have been found to be the most effective method of controlling asbestos emissions from manufacturing processes. In asbestos mining, small fabric filters are used for control during drilling. Cyclones, bag collectors, and properly designed ducts are then used for dust control in the crushing operation. Cyclones, sometimes followed by baghouses, are used as control devices on dryers.

An air standard has been promulgated for a number of major commercial sources of asbestos fibers. Effluent guidelines have been promulgated which, together with the National Pollutant Discharge Elimination System (NPDES) permit system, should reduce asbestos discharges. Additional regulatory actions, control options, and attendant impacts concerning asbestos are shown in Table 1.

Based on the information presented in this report, the following items need to be considered in future studies:

- long-term low-level health effects of airborne and waterborne asbestos.
- environmental behavior and persistence of asbestos.
- rates of emissions and effluents from mining, fabrication and consumption processes.
- possibility of asbestosis or cancer risk to the general public from asbestos in air, water, food, and beverages.

SECTION 3

SOURCE DESCRIPTION

Asbestos, the name applied to a number of fibrous mineral silicates, is found naturally in irregular veins scattered throughout rock masses in various parts of the world. The silicates may be divided into two large groups, one called serpentine (chrysotile) and the other amphibole which contains the minerals anthophyllite, amosite (ferroanthophyllite), crocidolite, tremolite, and actinolite.

PHYSICAL AND CHEMICAL PROPERTIES

Physical and chemical properties of various forms of asbestos differ considerably. Table 2 summarizes the properties of six varieties of asbestos (1).

PRODUCTION

Total asbestos output from United States mines was 102,071 metric tons in 1974 (2). Asbestos was produced in four states in 1974; California, with 53% of production, was the leader, followed in order by Vermont, Arizona, and North Carolina. Table 3 presents a listing of asbestos mines, locations, and types of asbestos mined in 1974.

PROCESS DESCRIPTION

Mining of asbestos is often done by trenching or open-pit methods, followed by underground mining by tunneling or block-caving methods. Milling practice, essentially a dry screening operation, consists of multiple stages of crushing, screening, aspirating the fiber from the rock, sifting, recleaning the fiber, and grading. Recleaning methods have been adopted to eliminate most dust and improve fiber grade quality. Huge baghouse installations have improved working conditions by reducing

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(1) Kirk-Othmer Encyclopedia of Chemical Technology, Second Edition, Vol. 2. John Wiley & Sons, Inc., New York, New York, 1963. pp. 734-747.

(2) Clifton, R. A. Asbestos. In: Minerals Yearbook, 1974; Vol. 1: Metals, Minerals, and Fuels. U.S. Department of the Interior, Washington, D.C., 1976. pp. 179-189.

TABLE 2. PROPERTIES OF SIX ASBESTOS FORMS (1)

	Chrysotile	Anthophyllite	Amosite (ferroanthophyllite)	Crocidolite	Tremolite	Actinolite
Structure	in veins of serpentine, etc.	lamellar, fibrous asbestiform	lamellar, coarse to fine fibrous and asbestiform	fibrous in iron-stones	long, prismatic and fibrous aggregates	reticulated long prismatic crystals and fibers
Mineral association	in altered peridotite adjacent to serpentine, and limestone near contact with basic igneous rocks	in crystalline schists and gneisses	in crystalline schists, etc.	in iron-rich siliceous argillite in quartzose schists	in Mg limestones as alteration product of highly magnesian rocks, metamorphic and igneous rocks	in limestone and in crystalline schists
Origin	alternation and metamorphism of basic igneous rocks rich in magnesian silicates	metamorphic, usually from olivine	metamorphic	regional metamorphism	metamorphic	results of contact metamorphism
Veining	cross and slip fibers	slip, mass fiber unoriented and interlacing	cross fiber	cross fiber	slip or mass fiber	slip or mass fiber
Essential composition	hydrous silicates of magnesia	magnesium silicate with iron	silicate of iron and magnesium, higher iron than anthophyllite	silicate of sodium and iron with some water	calcium and magnesium silicate with some water	calcium, magnesium, iron, silicates, water up to 5%
Crystal structure	fibrous and asbestiform	prismatic, lamellar to fibrous	prismatic, lamellar to fibrous	fibrous	long and thin columnar to fibrous	long and thin columnar to fibrous
Crystal system	monoclinic (pseudo-orthorhombic?)	orthorhombic	monoclinic	monoclinic	monoclinic	monoclinic
Color	white, gray, green, yellowish	grayish white, brown, gray, or green	ash gray, greenish, or brown	lavender, blue, greenish	gray-white, greenish, yellowish, bluish	greenish
Luster	silky	vitreous to pearly	vitreous, somewhat pearly	silky to dull	silky	silky

(continued)

TABLE 2. (continued)

	Chrysotile	Anthophyllite	Amosite (ferroanthophyllite)	Crocidolite	Tremolite	Actinolite
Hardness, S	2.5 - 4.0	5.5 - 6.0	5.5 - 6.0	4	5.5	6
Specific gravity	2.4 - 2.6	2.85 - 3.1	3.1 - 3.25	3.2 - 3.3	2.9 - 3.2	3.0 - 3.2
Cleavage	010 perfect	110 perfect	110 perfect	110 perfect	110 perfect	110 perfect
Optical properties	biaxial positive extinction parallel	biaxial positive extinction parallel	biaxial positive extinction parallel	biaxial extinction inclined	biaxial negative extinction inclined	biaxial negative extinction inclined
Refractive index	1.50 - 1.55	1.61	1.64	1.7 pleochroic	1.61	1.63 weakly pleochroic
Fusibility, Seger cones	fusible at 6, 1,190° - 1,230°C	infusible or difficultly fusible	fusible at 6, loses water at moderate temperatures	fusible at 3, 1,145° - 1,170°C	fusible at 4, 1,165° - 1,190°C	fusible at 4, 1,165° - 1,190°C
Flexibility	very flexible	very brittle, nonflexible	good, less than chrysotile	fair to good	generally brittle, sometimes flexible	brittle and nonflexible
Length	short to long	short	5 cm to 30 cm varies	short to long	short to long	short to long
Texture	soft to harsh, also silky	harsh	coarse but somewhat pliable	soft to harsh	generally harsh, sometimes soft	harsh
Acid resistance	soluble up to approximately 57%	fairly resistant to acids	fairly resistant to acids	fairly resistant to acids	fairly resistant to acids	relatively insoluble in HCl
Spinnability	best	poor	fair	fair	generally poor, some are spinnable	poor
Specific heat, J/kg-K	946	879	908	841	888	908

TABLE 3. U.S. ASBESTOS MINES

State and company	County	Name of mine	Type of asbestos
Arizona: Jaquays Mining Corp.	Gila	Chrysotile	Chrysotile
California:			
Atlas Asbestos Corp.	Fresno	Santa Cruz	Chrysotile
Coalinga Asbestos Co., Inc.[a]	Fresno	Christie	Chrysotile
Pacific Asbestos Corp.[a]	Calaveras	Pacific Asbestos	Chrysotile
Union Carbide Corp.	San Benito	Santa Rita	Chrysotile
North Carolina:			
Powhatan Mining Co.	Yancey	Hippy	Anthophyllite
Vermont: GAF Corp.	Orleans	Lowell	Chrysotile

[a]Closed at end of 1974.

dusts in the mills and recirculating the clean filtered air back into the working areas. Baghouse dusts are also graded and sold as fillers. Most fibers are pressure-packed ready for shipment, thus improving warehousing and shipping facilities (1).

USES

The greatest use of asbestos is in the manufacture of asbestos cement products made primarily by wet processes. The second largest use of asbestos is in asphalt and vinyl floor tiles. Asbestos is used in a variety of industries as shown in Table 4, which shows the diversity of products in which asbestos may be used. A total of 659 plants have been identified in the various industries shown (3).

In 1974, 12% of all asbestos consumed in the United States was produced in U.S. mines, the rest being imported. Chrysotile is by far the most commonly used form of asbestos, accounting for over 94% of U.S. consumption in 1974. Most chrysotile fibers are used in manufacturing asbestos cement pipes, asbestos cement sheets, and flooring products as shown in Table 5 (2). Primary chrysotile uses include friction products, sealants, sidings, tiles, guttering, and waste pipes for the construction industry.

From Table 5, crocidolite is the next most commercially important form of asbestos. It is used primarily in the construction

(3) Moll, K., S. Baum, E. Capener, F. Dresch, R. Wright, G. Jones, C. Starry, and D. Starrett. Hazardous Wastes. A Risk-Benefit Framework Applied to Cadmium and Asbestos (PB 257 951). U.S. Environmental Protection Agency, Washington, D.C., September 1975. 272 pp.

TABLE 4. U.S. ASBESTOS USES (3)

Asbestos - cement industry:
- Shingles for roofing and siding
- Wall sheets
- Insulation board
- Clapboard
- Electric motor casings
- Water and sewage pipes
- Gas pipes
- Rain gutters
- Air ducts
- Refuse chutes

Asbestos - textile industry:
- Fireproof theater curtains
- Lagging
- Other insulation wrapping
- Conveyor belting
- Safety clothing
- Potholders
- Ironing board covers
- Draperies
- Rugs
- Motion picture screens
- Gas filters in gas masks
- Filters for processing fruit juices
- Filters for processing acids
- Filters for processing beer
- Filters for processing medicine
- Mailbags
- Prison-cell padding
- Airplane fittings
- Stove and lamp wicks
- Sparkplugs
- Fire hose

Electrical equipment industry:
- Insulation tape

Asbestos papers, felts, and millboard:
- Roofing
- Piano padding
- Stove and heater linings
- Filing cabinet linings
- Military helmet linings
- Automobile hood mufflers
- Boiler jackets
- Radiator covers
- Acoustical ceilings
- Plasterboard
- Fireproof wallboard
- Electrical switch boxes
- Safes
- Table pads
- Stove mats
- Ovens
- Dry kilns

Asbestos plastics:
- Flooring tiles (asphalt and vinyl binders)
- Reinforcement and filler in plastics
- Plastic products (frying-pan handles, rocket nose covers)

Miscellaneous:
- Ingredient of paints and sealants
- Component of roof coating and road-building compounds
- Putty, caulk, and other crack fillers
- Artificial snow
- Spray insulation on structural steel
- Undercoating on automobile bodies
- Gaskets and packing materials
- Insulation materials

Friction materials:
- Brake linings
- Clutch facings

TABLE 5. ASBESTOS DISTRIBUTION BY END USE AND TYPE, 1974 (2)

	Asbestos type, metric tons				
End use	Chrysotile	Crocidolite	Amosite	Antho-phyllite	Total asbestos
Asbestos cement pipe	167,980	33,020	1,000	180	202,180
Asbestos cement sheet	82,090	-[a]	3,900	-	85,990
Flooring products	139,230	-	-	-	139,230
Roofing products	66,940	-	1,540	-	68,480
Packaging and gaskets	26,030	90	-	-	26,120
Insulation, thermal	6,620	-	1,630	-	8,250
Insulation, electrical	4,260	-	-	-	4,260
Friction products	72,200	-	-	180	72,380
Coatings and compounds	34,380	-	-	-	34,380
Plastics	15,330	180	-	630	16,140
Textiles	18,500	-	-	-	18,500
Paper	57,230	180	-	-	57,410
Other	33,020	360	450	-	33,830
TOTAL	723,810	33,830	8,520	1,000	767,160

[a]Not applicable.

trades and the manufacture of paper, acid-resistant gaskets, filters, and marine insulation. Amosite and then anthophyllite rank below crocidolite in commercial importance. Amosite is used primarily for construction industry products, roofing products, and thermal insulation. Anthophyllite is used as a filler in plasticware and to a lesser extent in construction industry products and friction products.

Asbestos was used in spray insulation in buildings between 1950 and 1972. This may become a major source of environmental discharge as buildings constructed during this period are demolished (4).

(4) Summary Characterizations of Selected Chemicals of Near-Term Interest. EPA 560/4-76-004 (PB 255 817). U.S. Environmental Protection Agency, Washington, D. C., April 1976. 50 pp.

SECTION 4

ENVIRONMENTAL SIGNIFICANCE AND HEALTH EFFECTS

ENVIRONMENTAL SIGNIFICANCE

Emission Sources

Tracing various paths through which asbestos enters the environment is complicated by the fact that asbestos has approximately 3,000 uses (3). Asbestos enters the atmosphere from so many sources that its presence may be regarded as ubiquitous, with only a small portion of the fibers arising from natural sources. Figure 1 presents a flowchart showing asbestos production, fabrication, consumption, and estimated disposal quantities in the United States in 1972. From these estimates, it may be concluded that mining and milling result in the majority of atmospheric emissions, while asbestos fabrication in the construction industry results in the major asbestos water emissions.

Corresponding to Figure 1, Table 6 shows the major industrial sources of asbestos emissions. Also shown are the number of plants for each product group and the respective surrounding population density.

Table 7 shows estimated asbestos emission factors for mining and milling, processing into products, and consumption of end-use items.

Emission Levels

Significant quantities of asbestos fibers appear in rivers and streams draining from areas where asbestos-rock outcroppings are found. Asbestos fibers have been found in a number of drinking water supplies, but corresponding health implications of ingesting asbestos are not fully documented (4). Asbestos enters water systems by airborne settling, dumping of waste effluent from mining and milling operations, and dumping of asbestos-bearing wastes. Recent evidence indicates that asbestos is leached from asbestos-cement pipes in municipal water systems. In 1975, asbestiform fibers were found in 10 widely separated potable water supplies ranging in concentration from 0.25×10^3 fibers/m^3 to 240×10^3 fibers/m^3. Long asbestos fibers have been found to cause clogging of household appliances in some cities where asbestos-cement pipe is leached heavily by the water (3).

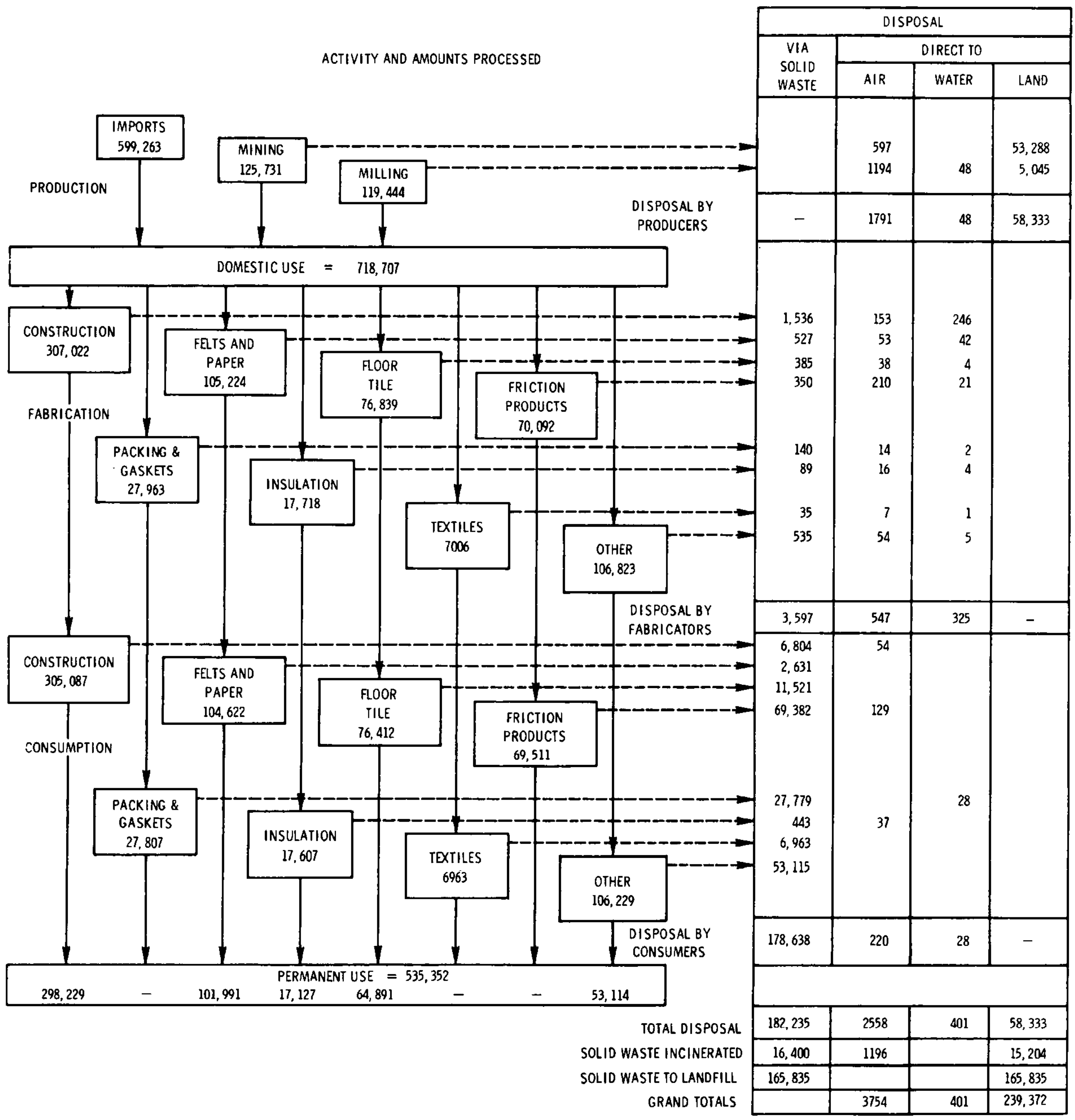

Figure 1. Asbestos production, fabrication, consumption, and disposal quantities in the U.S. (metric tons/yr in 1972).

TABLE 6. ASBESTOS PRODUCTS INDUSTRY AIR EMISSIONS AND SURROUNDING POPULATIONS (3)

Product group	Total emissions, metric tons/yr	Number of plants	Surrounding population density, people/km^2
Construction	153	48	1,720
Floor tile	38	18	2,960
Friction products	210	30	2,507
Paper and felt	53	29	1,687
Textiles	7	34	2,203
Gaskets, packing, and insulation	32	300	2,800
Other uses	54	200	2,300
TOTALS	547	659	2,374 average

TABLE 7. ASBESTOS EMISSION FACTORS FOR VARIOUS SOURCES

Emission source	Emission factor, kg/metric ton of asbestos produced
Mining, total	5
Mining	2
Leading	1
Hauling	1
Unloading	1
Mining, total, 50% control	3
Milling	50
Milling, 50% control	40
Milling, 80% control	10
Processing:	
Friction material, controlled	3
Asbestos-cement product, controlled	0.5
Textiles	20
Textiles, controlled	1
Asbestos paper	2
Asbestos paper, controlled	0.5
Floor tile	2
Floor tile, controlled	0.5
Consumptive uses:	
Brake linings	5
Steel fireproofing, controlled	5
Insulating cement, controlled	13
Construction industry	13

Exposure to asbestos fibers may occur throughout urban environments. Available data indicate that urban levels, averaging 29 ng/m^3, are much greater than nonurban concentrations, which generally appear to be less than 1 ng/m^3 (3). Urban concentrations are generated primarily from industrial sources or brake lining residues, although other major sources include building construction and demolition. Maximum atmospheric asbestos concentrations have been calculated using asbestos industry data. These calculations indicate that a maximum asbestos concentration of 6.2×10^{-9} g/m^3 will extend 1 km from an average operating asbestos plant (covering 2,060 km^2), and will fall off inversely with the square of further distances from the sources (3).

A recent study of street dust in Washington, D.C., showed approximately 50,000 fibers/g, much of which appeared to have come from brake linings (4).

HEALTH EFFECTS

The association of impaired human health with industrial exposure to asbestos is well known. Hundreds of cases of asbestosis (fibrosis of the lung) and pulmonary cancer associated with mining and milling of asbestos and manufacturing of asbestos products have been documented (5).

There is little evidence that low exposure to asbestos, such as what is encountered in ambient air, produces asbestosis or pulmonary carcinoma in human beings. These conditions have consistently been reported only from heavy industrial contact with asbestos. However, the discovery of association of a unique tumor (mesiothelioma of the pleura of the peritoneum) with very low exposure, or with casual contact with chrysotile asbestos (usually after a long latency period), has raised a question concerning human risk due to asbestos air pollution (5).

The following summary points have been listed for the epidemiology of asbestos (5):

- All major types of asbestos can cause lung cancer, although there are clear differences in risk with type of fiber and nature of exposure. Since exposure and response to asbestos are related, there is no excess risk when occupational exposure has been low.

- All commercial types of asbestos except anthophyllite may cause induction of mesothelioma. The risk is greatest with

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(5) Scientific and Technical Data Base for Criteria and Hazardous Pollutants-1975 ERC/RTP Review. EPA 600/1-76-023 (PB 253 942), U.S. Environmental Protection Agency, Research Triangle Park, North Carolina, January 1976. 464 pp.

crocidolite, less with amosite and apparently less with chrysotile. With the last two, there seems to be a greater risk in manufacturing than in milling.

- There is evidence of an association of development of mesotheliomas with air pollution near crocidolite mines and factories using mixed fibers. There is no excess risk from air pollution near chrysotile and amosite mines.

- There is, at present, no evidence of any cancer risk to the general public from asbestos in air, water, beverages, food or in fluids used for administration of drugs.

- Cigarette smoking enhances the risk of developing bronchogenic cancer in workers exposed to asbestos. No association between cigarette smoking and development of mesothelioma has been demonstrated.

- Pleural plaques (white patches on the lungs) are associated with past exposure to all commercial types of asbestos although not all pleural plaques are related to asbestos.

SECTION 5

CONTROL TECHNOLOGY

Fabric filters (baghouses) have been found to be the most effective method for controlling asbestos emissions from manufacturing processes (5). Typically, these baghouses use cotton fabric and automatic shakers. The usual capacity is 140 m^3/min to 570 m^3/min with an air-to-cloth ratio of less than 0.91 $m^3/min\text{-}m^2$ of cloth (6). According to the U.S. Environmental Protection Agency (EPA), baghouses can limit fiber concentrations (counting fibers longer than 5 μm) to fewer than 0.5/cm^3 of exhaust air (equivalent to weight concentrations of less than 25,000 ng/m^3). This standard is at the lower limit of detection by the optical microscope analytical method employed for asbestos measurements. Therefore, the currently proposed limit of 2 fibers/cm^3 appears technically feasible for effluent air streams from asbestos factories.

Although baghouses are the most successful control technology to date, they are not without their disadvantages. The most important disadvantages are: 1) relatively large installation area required for gas flow, 2) greatly reduced efficiency for even minor bag damage, 3) low cleaning efficiency after bag replacement, 4) high cost of bag replacement, and 5) upper limits on process temperature.

In asbestos mining, small fabric filters are used for control during drilling. Cyclones, bag collectors, and properly designed ducts are then used for dust control in the crushing operation. Cyclones, sometimes followed by baghouses, are used as control devices on dryers (6).

Asbestos milling involves crushing, separation from the dust by air aspiration, and grading the fibers by cyclones connected to the baghouses. Also connected to the baghouses are the screens, separators, recirculating systems, regrading areas, pressure packers, and other dust control systems, i.e., vacuum systems. Generally, all conveyors are covered, and low velocity hoods are used for control of dust in other areas (6).

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(6) Harwood, C. F., P. Siebert, and T. P. Blaszak. Assessment of Particle Control Technology for Enclosed Asbestos Sources. EPA 650/2-74-008, U.S. Environmental Protection Agency, Washington, D.C., October 1974. 135 pp.

The most common method of controlling emissions in open areas and waste piles is spraying with water or with aqueous and organic solutions of wetting agents, oils, and polymers. Physical and vegetative coverings are also used on waste piles. Water spraying is most commonly used in demolition of buildings. Vacuum systems and respirators are used in repair of pipes and boilers within buildings and ships.

Waste control technology for removing asbestos fibers from wastes is more involved and costly. Usually a combination of settling, sand filtration, diatomaceous earth filtration, and chemical coagulation is required, depending upon the amount of asbestos present and the degree of removal required. Research has been and is being conducted on coagulation and flocculation methods using ferric chloride, ferric hydroxide, calcium hydroxide, bentonite clay, and cationic polyelectrolyte.

Baghouses have been found to be the most effective method to control asbestos emissions from manufacturing processes and are currently in use in some segments of the asbestos industry. These devices can limit asbestos fiber concentrations (counting fibers longer than 5 μm) to fewer than $0.5/cm^3$ of exhaust air (equivalent to weight concentrations less than 25,000 ng/m^3) (5).

The control efficiency for asbestos milling emissions has been estimated to be 96%. Control efficiency, as well as control costs, vary proportionally with plant size for the industry. Considering only total costs of controlling asbestos emissions from all asbestos plants (using 1970 dollars), industry control costs equal $6,946,000 as shown in Table 8 (5). Assuming that the service life for control equipment is 10 years and that annual operational and maintenance costs, interest, insurance, and taxes together amounted to 20% of the original investment, the national annualized cost is calculated as $2,084,000/yr in 1970 dollars.

TABLE 8. ASBESTOS PRODUCTS INDUSTRY CONTROL COSTS (1970 DOLLARS)

Product group	Investments ($1,000)	Annualized costs ($1,000)
Construction	2,400	720
Floor tile	216	64.8
Friction products	720	216
Paper and felt	348	104.4
Textiles	1,700	510
Gaskets, packing, insulation	1,169	350.8
Other uses	393	117.8
Totals	6,946	2,083.8

Monitoring of plant asbestos concentrations represents a significant additional cost. In 1973, EPA estimated that the cost of determining the asbestos content of sprayable insulation material is in the range of $300/sample (using an electron microscope). Air sampling and subsequent analysis would be even more expensive. Based upon an instrument cost of $100,000 and a life of 10 years with 2 or 3 man-days per analysis, the cost of analyses for air sampling would probably be in the range of $700/sample. The national cost of surveying 659 plants once a year at this rate would total about $460,000/yr. (To sample once a month, the annual cost would be $5.5 million.) (5)

The national control and monitoring costs (one air sampling per year), then, would add to slightly more than $2,600,000. A 10% supplemental cost for enforcement would run the total national bill to about $2.9 million/yr (5).

SECTION 6

REGULATORY ACTION

An air standard has been promulgated for a number of major commercial sources of asbestos fibers. Asbestos is listed as a priority pollutant under the Federal Water Pollution Control Act which, together with the National Pollutant Discharge Emission System (NPDES) permit program, should reduce asbestos discharges. EPA is sponsoring an extensive national asbestos monitoring program; preliminary findings indicate that asbestos is a widespread contaminant of drinking water. The National Academy of Sciences (NAS) is reviewing the implications of these findings (4). Regulatory actions, control options, and attendant impacts concerning asbestos include (7):

Drinking Water Standard - Asbestos is one of the contaminants being considered in a study by the National Academy of Sciences on the health effects of contaminants in drinking water as a requirement of the Safe Drinking Water Act. The report deadline was December 15, 1976. Edgar Jeffrey, WSD, (214) 749-2106.

Hazardous Air Pollutant Standard - Iron ore beneficiation plants are being studied to determine the feasibility and desirability of extending coverage of current Hazardous Air Pollutant Standards to this possible source of asbestos. Gilbert Wood, OAQPS, (919) 688-8146 X-295.

Workplace Standard - A downward revision of the workplace exposure limit has been proposed. After economic impact studies are completed and public hearings have been held, the revised standard may be promulgated. William Warren, OSHA, (202) 523-7177.

Workplace Studies - The brake lining and clutch rebuilding industries are being studied to determine the best means for protecting workers. This classification of workers is not presently covered by workplace standards, and recommendations were to be sent to OSHA before the end of the year. John Dement, NIOSH, (513) 684-3191.

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(7) Identification of Selected Federal Activities Directed to Chemicals of Near-Term Concern. EPA 560/4-76-006 (PB 257 494), U.S. Environmental Protection Agency, Washington, D.C., July 1976. 36 pp.

Mine Safety Standard - The mine safety standards for metal and nonmetal industries, including asbestos, had a revision deadline of late 1976. H. P. Richardson, MESA, (202) 235-8307.

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4. Summary Characterizations of Selected Chemicals of Near-Term Interest. EPA 560/4-76-004 (PB 255 817). U.S. Environmental Protection Agency, Washington, D.C., April 1976. 50 pp.

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IERL-Ci project leader for this report is Dr. Charles Frank, 513-684-4481.

16. ABSTRACT

This report outlines the mining, milling, uses, and health effects of asbestos. Its major applications are in asbestos cement products, floor tiles, electrical equipment, brake linings, and flame resistant compositions. Impaired human health from industrial exposure to asbestos is well known. Additional information is needed on the effects of low level asbestos concentrations in air and water. Present control technologies, regulations, and major sources of pollution are reported and areas where information is needed are indicated.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Asbestos, crocidolite, Amphiboles, Fibers, Natural Fibers, Nonmetalliferous minerals, Silicate minerals, Asbestos Deposits, Serpentine, Mineral Deposits, Nonmetalliferous Mineral Deposits, Asbestos Cement Products, Concrete Products, Concrete Pipes, Shingles, Asbestosis, Occupational Diseases, Pneumonoloniosis, Pulmonary Fibrosis, Respiratory Diseases	Mining, Textiles, Construction, Plastics, Insulation, Friction Products	68A 68D 68G

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