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ASBESTOS

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July, 1982

ASBESTOS

1. PHYSICAL/CHEMICAL PROPERTIES AND CHEMISTRY

1.1 Properties

Fibrous asbestos minerals have found wide use because of a unique combination of resistance to heat and chemical attack, high tensile strength, and flexibility. Asbestos is found in thousands of commercial products including heat-resistant textiles, reinforced cement, filters, thermal insulation, and brake linings. As a consequence of the natural occurrence and wide use of this mineral, asbestos fibers are widely dispersed in the environment. Asbestos constitutes a health hazard for asbestos workers and is a potential threat unless it is completely sealed into a product (NIH, 1978; IARC, 1977).

Asbestos is a common name for a group of natural silicate minerals that separate into thin but strong fibers. Current usage of the term asbestos is usually reserved for the serpentine mineral chrysotile, and five fibrous minerals in the amphibole class (see Table 1). Identification of asbestos fibers is relatively simple with bulk samples due to the unique characteristics of these minerals; however, positive identification is difficult for submicroscopic samples. For regulatory purposes, asbestos has been defined as having a length to diameter (aspect) ratio of 3:1 or greater. Chrysotile is the major mineral form of asbestos and accounts for more than 95% of the fiber presently used in the United States (NIOSH, 1980).

1.2 Chemistry and Environmental Fate/Transport

Asbestos minerals are composed of silicon, oxygen, hydrogen, and various metal cations (sodium, magnesium, iron, calcium). Typical formulas for asbestos are given in Table 1 along with important properties and uses. Asbestos minerals are resistant to chemical attack; chrysotile, however, is susceptible to degradation by acids. All forms of asbestos will decompose to simpler components (i.e., pyroxenes and silica) when heated to temperatures in the range 600–1000°C (OWRS, 1979; Michaels, 1979).

Dry asbestos easily separates and forms dust which consists of fibers varying from several inches to microscopic in size. These microscopic fibers are hazardous and may remain in the atmosphere long enough to travel great distances. Because asbestos persists in the environment it can be widely redistributed by natural and human means. While not water soluble, asbestos may remain in suspension and travel great distances. The surface of asbestos fibers in water may carry either a net positive (chrysotile) or negative (amphiboles) charge. These charged surfaces permit the formation of stable suspensions in water. Some materials, notably trace metals and organic compounds, may be adsorbed onto or react with asbestos surfaces. Bioaccumulation and biotransformation processes are not significant in aquatic organisms. Suspended asbestos fibers eventually undergo physical

TABLE 1: PROPERTIES OF ASBESTOS FIBERS[a]

Name	CAS Number and General Formula[b]	Decomposition[c] Temperature (°C)	Properties	Uses
Chrysotile	12001-29-5 $Mg_3Si_2O_5(OH)_4$	800-850	Usually white or pale in color; flexible, silky, and tough; high tensile strength.	Widely used in cement sheets & pipes, floor and ceiling materials, and friction products.
Crocidolite	12001-28-4 $Na_2(Mg,Fe)_5Si_8O_{22}(OH)_2$	800	Blue color, flexible, brittle and tough; high tensile strength.	Sparingly used for asbestos cement pipe.
Amosite	12172-73-5 $(Mg,Fe)_7Si_8O_{22}(OH)_2$	600-900	Usually pale brown and brittle.	Some use in asbestos cement sheet and as thermal insulation.
Anthophyllite (fibrous)	17068-78-9 $(Fe,Mg)_7Si_8O_{22}(OH)_2$	950	White in color and brittle; talc-like form.	Limited use in composite materials (plastic resins).
Actinolite (fibrous)	13768-00-8 $Ca_2(Mg,Fe)_5Si_8O_{22}(OH)_2$	1040	Pale to dark green in color.	Fibrous actinolite is of no commercial significance.
Tremolite (fibrous)	14567-73-8 $Ca_2(Mg)_5Si_8O_{22}(OH)_2$	1040	White to grey; usually brittle.	Fibrous form has no significant uses, but is an impurity in talcs.

[a] Source: (Michaels, 1979) unless otherwise noted.

[b] (OWRS, 1979).

[c] Typical temperature peak or range observed during differential thermal analysis (DTA) of the thermal breakdown to simpler products in an inert atmosphere.

degradation or chemical coagulation which allows them to settle into the sediment. Environmental release of asbestos occurs primarily through disposal of consumer wastes to land. Disposal to the land is also an important source of atmospheric asbestos (NIH, 1978; OWRS, 1979).

2. EFFECTS INFORMATION

2.1 Health Effects (CONTACT: Jerry Stara, FTS 684-7531; Les Grant, FTS 629-2266; Bob McGaughy, FTS 755-3968; Ed Ohanian, FTS 472-6820)

Disposition of Fibers in the Body

The disposition of inhaled asbestos fibers depends primarily on fiber size. Certainly some fibers are ultimately deposited in the airways and lung tissue. Some could also be expectorated or conveyed to the gastrointestinal tract by airway clearance mechanisms and possibly some to the pleural and peritoneal cavities via lymphatic drainage.

Of asbestos fibers found in human lungs, a majority are less than 5 um in length and seldom do they exceed lengths of 200 um or diameters of 3.3 um. One autopsy study of persons with occupational exposure demonstrated that all asbestos fibers examined in the lung were less than 0.5 um in diameter. This preponderance of small fibers in part reflects their ability to remain suspended in air for longer periods than larger fibers, but it is also a function of their deposition and clearance characteristics once they enter the respiratory tract. Studies with mammalian cells in culture indicate that these shorter fibers (usually less than 5 um) may be engulfed by alveolar macrophages and transported to lymphatic channels or the mucociliary blanket for excretion. Longer fibers may be only partially engulfed or may be engulfed by several macrophages at once (NIH, 1978).

Asbestos fibers may enter the gastrointestinal tract via the diet, or by ingestion of inhaled fibers cleared from the respiratory tract. While most of the swallowed asbestos is probably excreted in the feces, microscopic fibers can migrate through the gastrointestinal mucosa. Recent studies show significant asbestos levels in tissue samples (liver, jejunum, lung) of humans due to transmucosal uptake of fibers ingested by drinking asbestos contaminated water. Ingestion of asbestos by humans has been shown to lead to asbestos fibers in urine; this result also provides evidence for transmucosal passage of mineral fibers. Animal studies of gastrointestinal tract penetration by asbestos fibers have yielded conflicting results (OWRS, 1980).

2.1.1 Acute Toxicity

Acute effects are of little consequence in inhalation exposure to high asbestos concentrations. Temporary breathing difficulty due to air-flow abnormalities may result from short-term exposure to high levels.

2.1.2 Chronic Toxicity

Nearly all the positive evidence linking asbestos to human disease has come from occupational studies. Asbestosis requires the greatest degree of exposure, followed by bronchial carcinoma and mesothelioma, in that order. However, development of these diseases follows the opposite trend, so that heavy exposure to asbestos may lead to death by asbestosis or bronchial carcinoma long before mesothelioma arises (OWRS, 1980).

Asbestosis - Asbestosis is a long-term disease resulting from inhalation of asbestos fibers. Fibrous tissue is generated around the alveoli of the lungs and the thickened membranes impede the interchange of carbon dioxide and oxygen. Severely affected people develop shortness of breath and may eventually die of heart failure. All varieties of asbestos appear capable of producing asbestosis (NIH, 1978).

Carcinogenicity Mutagenicity and Teratogenicity - Exposure to airborne asbestos fibers has been conclusively shown to cause bronchial carcinoma (lung cancer), mesothelioma (a rare cancer of the membranes lining the chest and abdomen), and gastrointestinal tract cancers (IARC, 1977; NIH, 1978; OWRS, 1980).

Bronchial cancer is the major exposure-related cancer affecting asbestos workers. All commercially available asbestos forms are linked with increased incidences of lung cancer to varying degrees. Evidence indicates that combined exposure to both asbestos and cigarette smoke greatly increases the risk of lung cancer. Almost all reported cases of mesothelioma have been associated with exposure to asbestos. Epidemiological studies suggest that all commercial forms of asbestos (except possibly anthophyllite) may cause mesothelioma. There does not appear to be a synergistic effect between asbestos and cigarette smoking regarding mesothelioma (OWRS, 1980; IARC, 1977).

Epidemiological studies have shown that workers exposed to airborne asbestos also incur increased risks of developing cancers of the gastrointestinal tract (throat, stomach, colon, rectum). In the one study in which synergism has been investigated, esophagus cancers were increased in incidence only among smoking asbestos workers, not in their non-smoking co-workers. Stomach and colon-rectum cancer showed no smoking relationship. Cancers of the oropharynx and larynx were also concentrated among the smoking asbestos workers (OWRS, 1980; NIH, 1978).

For asbestos-related GI cancers discussed above, such exposure occurs principally via inhalation and by swallowing asbestos fibers cleared from the lung (in the sputum), and by ingestion of fibers trapped in the nose or mouth. However, no definitive study exists which establishes risk levels for ingested asbestos alone. To date, the studies which have examined the effects of asbestos in drinking water are not conclusive. Also, two forms of asbestos (chrysotile and amosite) were recently found not to be carcinogenic in large-scale feeding experiments using hamsters (National Toxicology Program).

Chromosal aberrations in hamster cells due to asbestos have been observed. However, mutagenicity in several bacterial systems was not observed in testing with various forms of asbestos. No data exist that link teratogenic effects with exposure to asbestos fibers, although transplacental transfer of asbestos has been reported (OWRS, 1980).

2.2 Environmental Effects

2.2.1 Aquatic Effects

No freshwater or saltwater organisms have been tested with asbestos minerals. The only available data result from field studies in which chrysotile and amphibole fibers were found in fish samples taken from freshwater with known concentrations of these fibers. While muscle tissue does not appear to accumulate asbestos, bioconcentration may occur in fish liver and kidney (OWRS, 1980).

3. ENVIRONMENTAL RELEASE (CONTACT: Phillip Cook, FTS 783-9523; William Brungs, FTS 838-4843)

Chrysotile is the major type of asbestos used in the manufacture of asbestos products. These products include asbestos cement pipe, flooring products, brake linings and clutch facings, roofing products, and coating and patching compounds (see Table 2). Most of the asbestos used in the United States is imported; in 1980, for example, 80 kkg were produced in this country while 328 kkg were imported. Domestic use of asbestos has decreased significantly in recent years due, in part, to the well publicized undesirable health effects; e.g., 1980 consumption was less than one-half of 1972 consumption (SRI, 1982).

Total releases of asbestos to the U.S. environment have been estimated to be about 240,000 kkg (for 1980). Major sources include asbestos mining and milling; manufacturing and use of asbestos products; and disposal of asbestos wastes. Although these estimates are uncertain, several important conclusions are indicated (NIH, 1978).

- Land discharge accounts for nearly all releases; air emissions may total about 1% of asbestos released to the environment and water discharges are on the order of 0.2%.
- Solid waste disposal by consumers is by far the major discharge of asbestos.
- The potential for intermedia transfer of asbestos is significant due to its widespread use and persistence in the environment. For example, solid wastes produced from the manufacture and use of asbestos products, and from demolition can be emission sources of atmospheric asbestos. Water may become contaminated with asbestos due to: erosion from natural deposits; runoff from sites of asbestos disposal; and release of asbestos fibers from asbestos cement pipes used in water distribution systems.

3.1 Air Releases (CONTACT: Gilbert Wood or John Copeland FTS 629-5595)

Significant Sources

- Asbestos mining operations; ore and tailings dumps (SIC 1499)
- Surfacing of roadways with asbestos tailings (SIC 1499 and 1611)
- Asbestos milling (SIC 1499)
- Manufacturing of
    - asbestos cloth, cord, or other textiles (SIC 2200 and 3292)
    - asbestos cement (SIC 3292)
    - asbestos fireproofing and insulation materials (SIC 3292)
    - asbestos friction products (SIC 3292)
    - asbestos paper, millboard and felt (SIC 2661)
    - asbestos floor tile (SIC 3292)
    - paints, coatings, and caulks which contain asbestos (SIC 2850)
    - plastics and rubbers which contain asbestos (SIC 2821 and 2822)

- Chlorine production (SIC 2812)
- Demolition operations (SIC 1795)
- Use of spray-on asbestos materials (SIC 174)
- Open storage of asbestos materials (SIC 4221)
- Fabrication of asbestos products (SIC 3292)

Other Sources

- Transportation (consumption of asbestos brake linings)
- Mining of minerals containing trace amounts of asbestos
- Disturbance of asbestos-bearing overburden by off-road vehicles during mining and road-building or for recreation.

TABLE 2: DOMESTIC CONSUMPTION OF ASBESTOS (1980)

(kkg/yr and %)

Uses of Asbestos		kkg/yr	% of Total Uses
Asbestos cement pipe		144,000	40
Flooring products		90,000	25
Friction products		44,000	12
Roofing products		26,000	7
Packing and gaskets		13,000	4
Surface coats/sealants		11,000	3
Insulation		9,000	3
Asbestos cement sheet		8,000	2
Others		14,000	4
	Total	359,000	

Source: (SRI, 1982)

4. EXPOSURE ROUTES

There is little data available in the published literature on non-occupational exposures to asbestos. Occupational exposures are commonly reported as optical-microscope-visible fibers/cm^3 (or f/ml) greater than 5 um in length. However ambient levels are normally determined by transmission electron microscopy without a minimum length criterion. It is not known whether differences in fiber counts actually reflect differences in concentrations. In addition, techniques used to prepare samples for electron microscopic observation may cause alteration in fiber size.

4.1 Air Exposure (CONTACT: Gilbert Wood, FTS 629-5595)

Asbestos of the chrysotile variety is a ubiquitous contaminant of ambient urban air. Over 98 percent of the 24-hour samples monitored and analyzed had chrysotile asbestos concentrations of less than 20 ng/m^3 and most samples were less than 2 ng/m^3 (OWRS, 1980).

As one would expect, airborne asbestos can be found in the vicinity of asbestos mines, mills, manufacturing facilities, and waste dumps. But elevated levels of fibers also may be found near concentrations of braking vehicles, in buildings in which asbestos spray products have been used, and in cars and homes of asbestos workers who have contaminated them with dust brought from the work area on clothing, body, or equipment. Asbestos may be inhaled by persons who install their own asbestos roofing or flooring, or who repair such items as automobile brakes and clutches, home heating and plumbing systems, wires for toasters and waffle irons, or the walls of their homes (NIH, 1978).

Asbestos contamination has also been found in office buildings and schools where loose asbestos fireproofing material was applied to the structural steel surfaces. Current average exposure to asbestos in buildings containing accessible friable asbestos materials (i.e., materials not enclosed and easily crumbled or pulverized) has been estimated to be between 58 and 270 ng/m^3 (OPTS, 1980).

Most asbestos is incorporated into finished products where the fibers are bound in a matrix (e.g., asbestos-cement pipe and sheet, flooring and roofing products, and friction products), and this reduces the possibilities for air contamination. Yet, by the application of sufficient energy, fibers may be dislodged from even tightly bound materials; automobile brake linings are an example.

Clearly, there are opportunities for human non-occupational atmospheric exposure during installation, use, and repair of asbestos products. However, since there are so many products that use asbestos or materials that may be contaminated with asbestos, it would be next to impossible to estimate human exposure for each product type.

4.2 Water Exposure (CONTACT: Phillip Cook, FTS 783-9523; William Brungs, FTS 838-4843; Ed Ohanian, FTS 472-6820)

Asbestos, usually chrysotile, is commonly found in domestic water supplies. Generally asbestos of all sizes in water is expressed as fiber concentrations using electron microscope techniques. Some estimates relate chrysotile fiber concentrations to mass concentrations. It has been concluded that the majority (about 95 percent) of water consumers in the United States are exposed to asbestos fiber concentrations of less than 10^6 f/l. This is equivalent to the range of 2×10^{-4} to 2×10^{-3} ug/l in water supplies. The mass concentration of chrysotile asbestos in city water with less than 10^6 f/l are likely to be less than 0.01 ug/l, which is equivalent to a daily intake of less than 0.02 ug. However, in areas with significant contamination from natural sources, man's activities, or erosion from asbestos cement water pipes by aggressive water, the intake of asbestos from water can exceed 2 ug/day (OWRS, 1980).

Although the fate of the asbestos in inspired air is only approximately known, it appears that eventually more than half the asbestos inhaled will be swallowed. Assuming that an individual breathes 10 m^3 in 24 hours, most ambient air levels of chrysotile (1 to 10 ng/m^3) result in exposures to the gastrointestinal tract of from 0.01 to 0.05 ug/day of asbestos, although, in some circumstances, inhalation could produce gastrointestinal exposures exceeding 0.1 ug/day. These exposures are to be compared with those from water ingestion which lead to daily intakes of less than 0.02 ug. It would appear that inhalation can give rise to exposures at least equal to that of direct ingestion for most of the population of the United States (OWRS, 1980).

4.3 Other Exposure Routes

Food - There is little information on the contribution of food products to human asbestos exposure. Beers and wines could contain quantities of asbestos fibers similar to those found in water systems (10^6 to 10^7 f/l). This contamination could be from natural water sources or from the erosion of asbestos fibers from purifying filters. Contamination of drinking water by fibrous glass and other synthetic fibers used in cartridge filters has been measured at concentrations in excess of 10^9 f/l (OWRS, 1980).

Erosion of chrysotile from asbestos filters, used to purify parenteral drugs, up to 1 mg/dose have been noted in about one-third of drugs tested. Therefore, the Food and Drug Administration has prohibited the use of asbestos filters for drug purification, without subsequent cleanup (41FR16933).

Occupational - Only after 1966 has occupational monitoring attempted to quantify asbestos exposures by fiber counting techniques. Since then, considerable data have accumulated on occupational exposure of workers to asbestos. A large compilation of such data is included in the 1972 Asbestos Criteria Document (NIOSH, 1972). Levels during the period from 1966 through 1971 were generally under 10f (f>5um)/cm^3, although concentrations exceeding 100 f/cm^3 were observed, particularly in two plants producing amosite insulation materials and in uncontrolled textile mills. Data on earlier exposures are lacking although some estimates have been made of insulation-workers' exposure and factory environments (OWRS, 1980).

5. DATA BASES

5.1 Chemicals in Commerce Information System (CICIS)

The Inventory was compiled under the authority of Section 8 of TSCA which requires manufacturers to report to EPA the chemicals imported and manufactured during calendar year 1977. The Inventory lists the Chemical Abstract Service (CAS) preferred name for the chemicals, their respective CAS number (often used for identification purposes), production site, company name, and volume(s) of production and import. There is also a Confidential Inventory in which many of these characteristics are claimed confidential by the manufacturer. In these instances, the confidential information will not be available on the public inventory. CICIS can now be accessed through the NIH/EPA Chemical Information System (CIS - see 5.3). For further information, contact Gerri Nowack at FTS 382-3568.

5.2 EPA Chemical Activities Status Report (EPACASR)

EPACASR is an on-line system containing information on EPA's interest in chemicals. This system includes data on the Agency's regulations, research, and assessments directed toward specific chemicals. EPACASR is published annually and the data base is updated as information is received. A searchable subset itemizes NTP/NCI studies and results, as well as chemicals discussed in the IARC monograph series. (Other sources are added as appropriate.) Entries identify the statutory authority, the nature of the activity, its status, the reason for and/or purpose of the effort, and a source of additional information. Searches may be made by CAS Number or coded text. For further information contact Eleanor Merrick at FTS 382-3415.

5.3 NIH/EPA Chemical Information System (CIS)

This is a collection of various scientific data bases available through an interactive computer program. The linking system between these data files is the Structure and Nomenclature Search System (SANSS). CIS can also provide a list of non-CIS sources of information on a chemical of interest. However, these files have to be accessed individually by either separate on-line systems or in hardcopy. For further information contact Delores Evans at FTS 382-3546 or Irv Weiss at FTS 382-3524.

5.4 Chemical Regulations and Guidelines System (CRGS)

CRGS is an on-line data base which is being developed to provide information on chemical regulatory material found in statutes, regulations, and guidelines at the Federal, State, and International levels. Currently, only the first phase of CRGS, which encompasses only source material at the Federal level, is operational. Nationwide access to CRGS is available through Dialog. For further information, contact Delores Evans at FTS 382-3546 or Ingrid Meyer at FTS 382-3773.

5.5 Chemical Substances Information Network (CSIN)

The prototype CSIN, operational since November 1981, has been developed by merging the technologies of computer networking and distributed data base management. CSIN is not another data base, but a library of systems. Through the CSIN front-end intermediary management computer, the user may access and use independent and autonomous information resources which are geographically scattered, disparate for data and information content, and employ a variety of types of computer hardware, software, and protocols. Users may converse in and among multiple systems through a single connection point, without knowledge of or training on these independent systems.

Presently, six independent information resources are accessible through CSIN. They are: National Library of Medicine (NLM), CIS, EPA-CICIS, CAS-On-Line, SDC-orbit, and two files of Dialog: CRGS and TSCA Inventory. The CSIN management computer allows the user to create, retrieve, store, manipulate data and queries. This eliminates the need for re-entering long lists of chemical identifiers or other information elements which are part of the original query or which have been identified and acquired from one or more of the CSIN resources. For further information contact Dr. Sid Siegal at FTS 382-2256.

5.6 EPA Information Clearinghouse

The EPA Information Clearinghouse is a bibliographic data base composed of over 475 individual data bases and models which contain monitoring information and statistics on a variety of chemicals. The individual data bases are maintained by offices within EPA. For further information, contact Charlene Sayers at FTS 755-9112.

The following data bases contain information on asbestos:

BACT/LAER Determinations
Chemicals in Commerce Information System
Compliance Data System
Compliance Sampling Toxicant Surveys
Consolidated Permits Program-Application Form 1,2b,2c
Continuous Monitoring Subset
Data Collection Portfolio for Industrial Waste Discharges
Energy and Mining Point Source Category Data Base
Federal Facilities Information System
Fine Particle Emissions Information System
Food Industry Group
Fugitive Emissions Information System
Hazardous Waste Data Management System
Hazardous Waste Site Tracking System
Humacao Ambient Data Base
IFB Organics Data Base
Industrial Process Evaluations
Inorganic Chemicals Industry Regulation Record
Liquid Effluents Data System

Love Canal Data Handling System
National Pollutant Discharge Elimination System (NPDES) Discharge Monitoring Reports
Nationwide Urban Runoff Program
Needs Survey
New York Bight Ocean Monitoring Program
Organic Chemicals/Plastics Industry
Permit Compliance System
Pharmaceutical Screening/Verification Data Base
Priority Pollutants-Region I
Priority Pollutants-Region III
Publicly Owned Treatment Works (POTW) Quality Control
Puerto Rico Reservoirs
Regional Air Pollution Study-Point and Area Source
Regional Toxics Monitoring Program
Resource Conservation and Recovery Act (RCRA)-Hazardous Waste Site Inspections
Screening Sampling Program
Spill Prevention Control and Countermeasure
System for Consolidated Permitting and Enforcement Data Base
Textile Industry BAT Study-Toxic Sampling Data
U.S. Virgin Islands-St. Thomas, St. Croix
UPGRADE
Verification Data Base
Waste Characterization Data Base
Water Enforcement Regional System
Water Quality Information System
Wisconsin Power Plant Impact Study Data Center

6. REGULATORY STATUS (Current as of 12/80)

6.1 Promulgated Regulations

6.1.1 EPA Programs

Clean Air Act (CAA) (CONTACT: Gilbert Wood, FTS 629-5595)

- Section 112 - Asbestos is listed as a hazardous air pollutant and EPA has issued National Emission Standards (NESHAP). The standards prohibit any visible emissions of asbestos from milling, manufacturing, demolition, renovation, and spraying operations. Use of specified air cleaning procedures may be used in lieu of the no visible emission standard. These emission standards apply to the following product manufacturing operations (40CFR61):

  textile materials
  cement products
  fireproofing and insulation material
  friction products
  paper, millboard, and felt products
  floor tile
  paints, coatings, caulks, adhesives, sealants
  plastics and rubber materials
  chlorine
  shotgun shells
  asphalt concrete

For spray-on materials used for insulation or fireproofing, the standard limits asbestos content to no more than 1 percent. The use of friable asbestos in molded pipe insulation is prohibited. Also waste management operations for manufacturing, demolition, renovation, and spraying processes are regulated.

Clean Water Act (CWA)

- Sections 301, 304, 306, and 307 - Asbestos is listed as a Toxic Pollutant (40CFR401.15), also known as a priority pollutant, and is subject to effluent limitation guidelines. Guidelines have been promulgated for subcategories A through K of the asbestos manufacturing point source category. In addition, new point performance standards and pretreatment standards are also included in the regulations (40CFR427, Subparts A to K).

Toxic Substances Control Act (TSCA)

- Sections 4, 6, 7 and 8(a) - Naturally occurring chemical substances are included in the inventory reporting regulations. Asbestos is included under the definition of a naturally occurring chemical substance which is (1) unprocessed or (2) processed only by manual, mechanical or gravitational means; by dissolution in water; by flotation; or by heating solely to remove water (40CFR710).

- Section 12(b) - This regulation requires exporters of asbestos to notify the agency. This requirement applies to raw asbestos, although expansion to include asbestos-containing products is under consideration (40CFR707; 45FR82844).

- School Program - At present, the school asbestos technical assistance program is voluntary. Information on EPA's asbestos program is available from EPA regional offices or from headquarters in Washington, D.C. (800-424-9065).

Resource Conservation and Recovery Act (RCRA)

- Although asbestos was originally listed as a hazardous waste (45FR33066), it has been deleted because disposal of asbestos wastes is already regulated under the Clean Air Act (NESHAP). Consideration is being given to regulating asbestos wastes under RCRA and deleting waste disposal regulations under CAA in order to concentrate all waste regulations in one program office.

6.1.2 Programs of Other Agencies

CPSC - Consumer Product Safety Act

- Sections 8 and 9 - Consumer patching compounds and artificial emberizing materials (used in fireplaces to simulate live embers and ash) which contain asbestos are banned (16CFR1304 and 1305). General use garments containing asbestos are also banned (16CFR1500.17).

FDA - Federal Food, Drug, and Cosmetic Act

- Sections 501, 502, and 701 - The content of asbestos particles in parenteral (injectable) drugs is restricted (21CFR133).

- Sections 201(s), 409, and 701(a) - The use of the electrolytic diaphragm process in the production of salt for human consumption is prohibited due to asbestos impurities (21CFR121).

- FDA also regulates asbestos as a component in packing material (21CFR175.105) and food contact surfaces (21CFR177).

MSHA - Federal Metal and Nonmetallic Mine Safety Act

- Section 6 - Health and safety regulations exist for workers in mines concerning exposure to asbestos dust (30CFR55.5).

OSHA - Occupational Safety and Health Act

- Sections 6 and 8 - These regulations list definitions of asbestos, set permissible exposure limits, and describe methods for compliance, measurement, monitoring and recordkeeping (29CFR1910.1001 and 1910.1002).

DOT - Hazardous Materials Transport Act (HMTA)

- These regulations cover the packaging and shipping of asbestos materials (49CFR172 to 177).

6.2 Proposed Regulations

6.2.1 EPA Programs

CWA

- Criteria for ocean discharge have been proposed (45FR9549).

TSCA

- Reporting and recordkeeping requirements have been proposed for manufacturers, importers, and processors of asbestos (46FR8200).
- EPA has proposed rules requiring schools to identify friable asbestos materials (44FR54676, 45FR61966; corrections 46FR3033 and 46FR7011).

6.3 Other Actions

- SDWA - The possible development of a drinking water standard for asbestos depends upon ongoing health hazard assessments for ingested asbestos by epidemiological and animal studies.
- CAA - The asbestos NESHAP is currently undergoing revision.

7. STANDARDS AND RECOMMENDED CRITERIA[a]

7.1 Air

- OSHA permissible exposure limit (29CFR1910):

8 hr. TWA	2 f/cm^3[b]
ceiling concentration	10f/cm^3

- NIOSH recommended limits:

8 hr. TWA	0.1 f/cm^3[b]
ceiling concentration	0.5 f/cm^3

7.2 Water

• Water Quality Criteria for human health. This is a gastrointestinal cancer risk projected from occupational inhalation exposure and extrapolated to consumption of asbestos in drinking water (OWRS, 1980).	3×10^3 f/l for 10^{-5} risk

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[a] See Appendix A for a discussion of the derivation, use, and limitations of these criteria and standards.

[b] Fibers (f) longer than 5 micrometers per cm^3 of air using optical microscopy. Note that 1 f/cm^3 = 10^6 f/m^3.

8. SPILL OR OTHER INCIDENT CLEAN-UP/DISPOSAL (CONTACT: National Response Center 800-424-8802 in Washington 426-2675)

General Information

Very little information was available on the clean-up and disposal of asbestos spills. It is recommended that asbestos containing wastes be packaged in sealed bags or containers prior to transport or disposal in an approved landfill. Section 103(a) and (b) of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 requires persons who release hazardous substances into the environment in reportable quantities determined pursuant to Section 102 of the Act to notify the National Response Center (NRC): 800-424-8802 (Washington, D.C., 426-2675). The reportable quantity of asbestos is one pound.

9. SAMPLING, ACCEPTABLE ANALYTICAL TECHNIQUES AND QUALITY ASSURANCE

9.1 Air (CONTACT: Michael E. Beard, FTS 629-2623)

EPA has not promulgated an analysis methodology for asbestos. A method for measurement of airborne asbestos by transmission electron microscopy (TEM) has been developed and is in provisional use as evaluation of the technique continues. Airborne asbestos is collected by drawing air through a polycarbonate or cellulose ester filter and the fibers are then examined by TEM at a magnification of 20,000X. Fibers with an aspect ratio of 3:1 (length to width) or greater are counted and identified as possible asbestos by morphology. The fiber identity is confirmed as amphibole or serpentine (chrysotile) asbestos by determining crystal structure with selected area electron diffration (SAED) patterns and by determining chemical composition with x-ray fluorescence spectroscopy (XRF). Fiber concentration as fiber number and mass per cubic meter of air is reported. Detailed instructions for accomplishing the analysis are given in EPA-600/2-77-178 (Revised June, 1978), "Electron Microscope Measurement of Airborne Asbestos Concentrations, A Provisional Methodology Manual." Evaluation of this method is continuing (EPA Contract No. 68-02-3266) and further revision of the manual is anticipated.

A test of the provisional method by six laboratories gave a precision of 0.49 (ratio of spread between 95% confidence interval and mean value) for fiber number concentration and 1.57 for mass concentration on real samples containing chrysotile. A comparison of mass concentrations of laboratory prepared samples measured by the provisional method and by x-ray spectroscopy showed agreement within 10%. (EPA-600/2-78-038, June 1978).

9.2 Water (CONTACT: J. M. Long, FTS 250-3525)

More detailed information than that given below can be found in the "Interim Method for Determining Asbestos in Water" (EPA-600/4-80-005, January 1980). This method, although considered to be state-of-the-art, has not been designated as the approved procedure for determining asbestos in water.

Samples collected are treated with ultrasound for 15 minutes, and a known volume (generally 50-500 ml, depending on solids and asbestos concentration) of water sample is filtered through a 0.1 um Nuclepore filter to trap asbestos fibers. The filter is then carbon coated, a small portion of this filter with deposited fibers is placed on an electron microscope grid, and the filter material is removed by gentle solution in chloroform. The grids are then examined in a transmission electron microscope at a magnification of about 20,000X. The asbestos fibers are identified by their morphology and electron diffraction patterns and their lengths and widths are measured. The electron diffraction pattern obtained from the suspect fiber is compared with diffraction patterns from UICC standard material for confirmation as asbestos. The fiber must have an aspect ratio (length/width) greater than or equal to 3 to 1. The total area of the grid examined in the electron microscope is determined and the number of asbestos fibers in this area is counted. The concentration in million fibers per liter (MFL) is calculated from the number of fibers counted, the volume of sample filtered, and the ratio of the total filter area/sampled filter area. The mass per liter is calculated from the assumed density and the volume of the fibers.

Under favorable circumstances the detection limit is around 0.01 MFL (fiber concentration) corresponding to the order of 0.1 nanogram per liter (mass concentration). The common range of concentrations over which this procedure is applicable is from the limit of detection (0.01 MFL) up to about 900 MFL. Intra- and inter-laboratory precision for chrysotile analysis over this range is about 35%. For amphibole analysis intra-laboratory precision over the range is also about 35%; however, inter-laboratory precision for amphibole analysis is about 60%.

Mineral fibers that are occasionally misidentified as chrysotile asbestos are halloysite, palygorskite, and vermiculite. If the sample contains copious amounts of organic matter, this material can be removed by using Low Temperature Plasma Ashing. The ash is resuspended in water, refiltered on fresh nuclepore filter, and the particles are then counted.

Other methods for chrysotile (not amphibole) asbestos in water have been reported in "Development of a Rapid Analytical Method for Determining Asbestos in Water" (EPA-600/4-78-066). Chrysotile fibers are separated (75% recovery) from the bulk of other fibrous material by extraction into isooctane from water samples containing added anionic surfactant. The filtered isooctane fraction is then examined by microscope or by a visual color spot test. The reported detection limits are 100 nanogram per liter (10 MFL) for the color test and 1 nanogram (0.1 MFL) for the optical microscopy method.

9.3 Solid Waste (CONTACT: W. Beckert, FTS 595-2137; T. Hinners, FTS 595-2140)

Asbestos is no longer listed as a hazardous waste, and no pollutant measurements are required or specified for waste management procedures. If analysis of a waste for asbestos is desired the "Interim Method for Determining Asbestos in Water" (EPA-600/4-80-005) could be applied. If organic matter is collected in the filter and obscures the fibers, a specified low-temperature ashing procedure followed by refiltration is applicable.

9.4 Other Samples (CONTACT: Michael E. Beard, FTS 629-2623)

Bulk - While EPA has not promulgated an analysis methodology, an interim method for bulk sample analysis has been developed and is currently being evaluated.

The interim method has been developed primarily for the analysis of friable, sprayed-on insulation materials which may contain asbestos fibers. Core samples of the suspect material are taken with a clean container such as a 35mm film canister. Caution should be exercised during sampling to avoid generating dust; it is recommended that the material be lightly sprayed with water before sampling. At least three samples should be taken from each area homogeneous in appearance. Detailed instructions on sampling and survey program design are reported in EPA 560/13-80-017A, December 1980 (Asbestos-Containing Materials in School Buildings; Guidance for Asbestos Analytical Programs).

Samples are analyzed by polarized light microscopy (PLM). Samples may be treated to remove interferences such as binders and organic matrix material. Indentification of asbestos requires the observation of diagnostic optical properties for each fiber type in the sample. The relative area occupied by asbestos fiber within microscope fields of view is determined by a point counting technique. The relationship between relative area and weight percent of asbestos in a sample is currently being investigated. Multiple laboratory analysis of replicate samples containing a known weight percent of asbestos in a predominately gypsum matrix has provided some information on the performance of the iterim method. The bias of the method varies with asbestos type and weight percentage: for samples containing 10% chrysotile by weight, bias is 18.5%; for 50% chrysotile, bias is -24.2%; for 10% amosite, bias is 118.5%; for 50% amosite, bias is 12.1%. The coefficient of variation (CV) varies with the reported area percent value: at a mean reported value of 10% asbestos, CV = 79%; for 50% asbestos, CV = 41%. The rate of false negatives is such that the analysis of three samples of a suspect material, if each contained at least 5% asbestos by weight, would result in three false negatives with a probability less than 0.03 and possibly as low as 0.001.

The interim method includes procedures for x-ray powder diffraction (XRD) analysis should further information on a sample be required. It should be emphasized that XRD affords information only on crystal lattice structure and not on gross crystal morphology. Therefore, XRD cannot distinguish between the asbestos minerals and their non-asbestiform varieties. Particle morphologies must be determined by an optical technique such as PLM. It is therefore imperative that XRD be used <u>only</u> as a corroborative procedure with PLM and not as an independent analytical method. Although electron microscopy can be used for bulk samples, it is not recommended because only small quantities of sample can be analyzed at one time and multi-sample analysis becomes prohibitively expensive.

Procedures for Occupational Exposure

The "NIOSH Manual of Analytic Methods" contains several procedures for determining asbestos levels in air. A thermal analysis procedure and a microscopic counting method (<450-x magnification) are described in Volume I (1977, Procedures 245 and 239, respectively). Volume V (1977, Procedure 309) contains an x-ray diffraction procedure for chrysotile.

Note that data currently relating concentrations of fibers (>5 um) counted by optical microscopy to concentrations measured by electron microscopy are limited (estimates of the ratio of >5 um fibers counted by electron to optical methods range from 15:1 to 1000:1).

9.5 Quality Assurance (CONTACT: M. E. Beard, FTS 629-2623)

Asbestos reference materials are currently being developed by the National Bureau of Standards (NBS) through an interagency agreement with EPA. The materials will consist of filters deposited with chrysotile and various species of amphibole asbestos in an urban air particulate matrix and will be available in 1982. Prototypes of these devices are available on a limited basis.

An external quality assurance program for PLM analysis of bulk samples is currently available through the EPA Asbestos-in-Schools Program. Presently there are no QC samples for asbestos in water.

REFERENCES

The major references used in preparation of this document are listed below. EPA references are listed by EPA office of origin and the year of publication. For further information refer to contacts given throughout this document or contact the relevant EPA offices listed at the end of this section.

(IARC, 1977)	IARC Monographs on the Evidence of the Carcinogenic Risk of Chemicals to Humans, Vol. 14, International Agency for Research on Cancer, WHO (1977).
(Michaels, 1979)	Asbestos - Properties, Applications, and Hazards, Vol. 1, L. Michaels and S. Chissick, Eds., Wiley (1979).
(NIH, 1978)	Asbestos - An Information Resource, National Institutes of Health, DHHS pub. no. (NIH) 79-1681 (1978).
(NIOSH, 1972)	Criteria For a Recommended Standard - Occupational Exposure to Asbestos, National Institute for Occupational Safety and Health, DHH pub. no. (NIOSH) 72-169 (1972).
(NIOSH, 1980)	Workplace Exposure to Asbestos, National Institute for Occupational Safety and Health, DHHS pub. no. (NIOSH) 81-103 (1980).
(OPTS, 1980)	Support Document: Asbestos-Containing Materials in Schools, EPA-560/12-80-003, Office of Pesticides and Toxic Substances (1980).
(OWRS, 1979)	Water-Related Environmental Fate of 129 Priority Pollutants, Vol. 1, Ch. 7, EPA-440/4-79-029a, Office of Water Regulations and Standards (1979).
(OWRS, 1980)	Ambient Water Quality Criteria for Asbestos, EPA 440/5-80-022, Office of Water Regulations and Standards (1980).
(SRI, 1982)	Chemical Economics Handbook, "Asbestos-Salient Statistics", SRI International (1982).

OFFICE CONTACTS

The EPA offices and divisions that are listed below may be contacted for more information relating to the indicated sections of this document. While these offices are, in many cases, the offices of origin for the data included in this paper, the personal contacts given throughout this document should be contacted first. Unless otherwise noted, the offices listed are situated in Headquarters, Washington, D.C., and the telephone numbers given are FTS (Federal Telecommunications System) numbers. For commercial telephone calls to Headquarters which are not placed on FTS, area code 202 must be used. Other commercial numbers are noted for the office contacts located outside Washington, D.C.

HEALTH AND ENVIRONMENTAL EFFECTS (Section 2)

Office of Health and Environmental Assessment (OHEA)	
Environmental Criteria and Assessment Office:	
Cincinnati, OH	684-7531 (513-684-7531)
Research Triangle Park, NC	629-2266 (919-541-2266)
Carcinogen Assessment Group	755-3968
Office of Drinking Water (ODW)	
Health Effects Branch	472-6820
Office of Toxic Substances (OTS)	
Health and Environmental Review Division	382-4241
Environmental Research Laboratory	
Duluth, MN, Region V	783-9550 (218-727-6692)

ENVIRONMENTAL RELEASES AND EXPOSURE (Sections 3 and 4)

Office of Air Quality Planning and Standards (OAQPS)	
Strategies and Standards Division Research Triangle Park, NC	629-5504 (919-541-5504
Office of Water Regulations and Standards (OWRS)	
Monitoring and Data Support Division	426-2503

Office of Toxic Substances (OTS)

Exposure Evaluation Division	382-3873
Assessment Division	382-3442

DATA BASES (Section 5)

Office of Toxic Substances (OTS)

Management Support Division	382-3546

REGULATORY STATUS, STANDARDS, AND CRITERIA (Sections 6 and 7)

Office of Air Quality Planning and Standards (OAQPS)

Strategies and Standards Division Research Triangle Park, NC	629-5504 (919-541-5504)

Office of Drinking Water (ODW)

Criteria and Standards Division	472-5016

Office of Water Regulations and Standards (OWRS)

Criteria and Standards Division	755-0100
Effluent Guidelines Division	426-2571

Office of Solid Waste (OSW)

State Programs and Resource Recovery Division	755-9107

SPILL CLEAN-UP AND DISPOSAL (Section 8)

NOTE: For Emergenices call the National Response Center at 1-800-424-8802 (1-800-426-2675 from the Baltimore/Washington area).

Office of Emergency and Remedial Response (OERR)

Emergency Response Division	245-3045

Oil and Hazardous Materials Spills Branch

Edison, NJ; Region II	340-6634 (201-321-6634)

Office of Solid Waste (OSW)

Hazardous and Industrial Waste Division	755-9187

ANALYTICAL TECHNIQUES (Section 9)

Environmental Monitoring Systems Lab (EMSL)

Air Analysis Research Triangle Park, NC	629-2454 (919-541-2454)
Water Analysis Cincinnati, OH	684-7311 (513-684-7311)
Waste Analysis Las Vegas, NV	545-2137 (702-798-2137)

GENERAL IPP COMMENTS, CORRECTIONS, OR QUESTIONS

Office of Toxic Integration

Chemical Information and Analysis Program	382-2249