Chapter 1
Asbestos Properties and Regulation

Asbestos History and Characteristics

History of Asbestos Use

Thousands of years ago, ancient people discovered that certain rock fibers could be woven into a tough fabric that would not burn. This material, known as "asbestos" (a term incorrectly derived from a Greek word meaning “inextinguishable") was used to create lamp wicks, clothing, cremation cloths and other woven materials.

Use of asbestos fabric continued throughout the ages. It has been reported that Emperor Charlemagne (A.D. 742-814) impressed his enemies with the incombustible properties of a tablecloth and that Benjamin Franklin, in 1725, similarly impressed his London host by tossing a purse made of asbestos into a lit fireplace.

The properties of asbestos were not generally known and asbestos was not commercially available until the mid-1800s when commercial production of asbestos products began in Italy and subsequently spread to the British Isles and North America. During this time the Industrial Revolution, spurred by the expanding use of the steam engine, fostered the growth of the gasket and insulation industries where the properties of the "miracle fiber," asbestos, were soon recognized and put to use.

In the late 1870s, large deposits of asbestos were discovered in Canada. Asbestos has also been found and commercially mined in other countries including Australia and South Africa and in the United States in Arizona, California, Georgia, New Hampshire, North Carolina, Vermont and Virginia.

Asbestos product use in America was greatest from the 1940s until the late 1970s when the health hazards associated with asbestos exposure became widely recognized. By this time asbestos had become an integral component of approximately 3,600 commercial products. During World War II, enormous quantities of asbestos were used in shipbuilding and other industries. Following the war and until the late 1970s, asbestos was widely used in buildings for fireproofing, thermal and acoustical insulation, condensation control and decoration.

It has been estimated that approximately 30 million tons of asbestos have been used in the construction and manufacturing industries since the early 1900s.

Geological Information

“Asbestos” is a term used to describe six naturally occurring incombustible minerals. Asbestos minerals were formed millions of years ago when heat, pressure and resultant chemical activity changed the physical and chemical characteristics of preexisting rock. Unlike other minerals

which consist of tightly bound crystals, asbestos minerals are characterized by the presence of densely packed bundles of fibers.

Asbestos Minerals

Asbestos minerals are extracted from asbestos ore obtained via surface and subsurface mining operations throughout the world. Once extracted, asbestos ore is crushed, screened, milled (ground) to appropriate size and graded. The resultant fine thread-like fibers are actually aggregates of hundreds of thousands of loosely bound fibers, each of which can be further subdivided into "fibrils." Fibrils can be observed only with an electron microscope.

Asbestos minerals are divided into two major classes, serpentine and amphibole asbestos, which differ from one another both physically and chemically. (See Figure 1-1.)

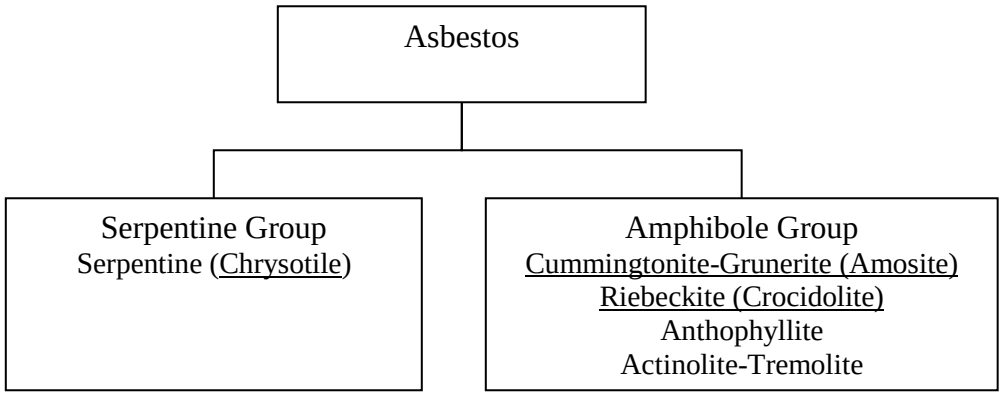

Figure 1-1.

The serpentine group contains only one asbestos mineral, chrysotile. Its scroll-like white fibers are very fine (0.02-0.08 micrometers (µm) in diameter), flexible and heat resistant and exhibit high tensile strength. Because of these characteristics, chrysotile has been incorporated into thousands of commercial products including insulation, cement products and roofing materials and consequently is the type of asbestos most commonly found in buildings in the United States and throughout the world. The amphibole group contains five asbestos minerals: actinolite, amosite, anthophyllite, crocidolite and tremolite. Of these, however, only amosite, a brown asbestos with brittle, needle-like fibers (0.06-0.35 µm in diameter), has been used extensively, primarily in high-temperature applications where great thermal resistance is needed. Amosite is commonly found in high-pressure steam line and boiler block insulation. Crocidolite was the least used of the various forms of commercial asbestos products. Approximately 10% of the asbestos used in the United States was crocidolite.

Since "asbestos" was defined within regulations as the six minerals making up the serpentine and amphibole groups, other amphiboles have been found to cause asbestos disease – notably richterite and winchite found in vermiculite mined in Libby, Montana. Vermiculite, a micaceous mineral, is used in many different products including insulation, fireproofing materials and soil conditioners. There have been legislative efforts to add richterite and winchite to the list of regulated asbestos minerals. Other amphiboles may also be targeted for future regulation due to their association with asbestos-related disease.

Table 1-1 provides a brief synopsis of the mineralogy and chemistry of asbestos minerals.

Table 1-1. The Asbestos Minerals.

Class	Name	Nominal Composition	Characteristics
Serpentine	Chrysotile	$Mg_3Si_2O_5(OH)_4$	White asbestos. Fine, silky, wavy fibers. Flexible and high tensile strength.
Amphiboles	Amosite	$(Mg, Fe)_7Si_8O_{22}(OH)_2$	Brown asbestos. Straight, rigid fibers. High thermal resistance.
	Actinolite-Tremolite	$Ca_2(Mg, Fe)_5Si_8O_{22}(OH)_2$	Colorless to pale green. Rarely used.
	Anthophyllite	$(Mg, Fe)_7Si_8O_{22}(OH)_2$	Brittle white fiber. Rarely used.
	Crocidolite	$NA_2FE^2{}_3+Fe^3{}_2+Si_8O_{22}(OH)_2$	Blue asbestos. Straight, rigid fibers.

Asbestos Fibers

Since the 1960s, employers, regulators and researchers have monitored workplaces where asbestos products were being installed, manufactured or used. Air samples obtained in workers' breathing zones are analyzed by phase contrast microscopy (PCM). Using PCM, any particle that has an aspect ratio greater than or equal to 3:1, a length greater than 5 µm and a width less than 3 µm is considered an asbestos fiber. PCM is the method required by the federal Occupational Safety and Health Administration (OSHA) for asbestos-related air sample analysis. Since the OSHA-defined fiber became the principal occupational exposure measurement, a more specific definition for the physical properties of asbestos fibers was published in the U.S. Environmental Protection Agency's (EPA's) *Method for the Determination of Asbestos in Bulk Building Materials*, EPA/600/R-93/116, July 1993.

As stated in this document, asbestiform minerals, when viewed by polarized light microscopy (PLM) as prescribed in bulk sample analysis procedures, generally have the following characteristics:

- Mean aspect ratios ranging from 20:1 to 100:1 or higher for fibers longer than 5 µm (with aspect ratios being determined for fibers, not bundles);
- Very thin fibrils, usually less than 0.5 µm in width; and
- Two or more of the following:
    - parallel fibers occurring in bundles;
    - fibers displaying splayed ends;
    - matted masses of individual fibers; and/or
    - fibers showing curvature.

Figure 1-2 illustrates the relatively small diameter of asbestos fibers compared to other commonly recognizable materials.

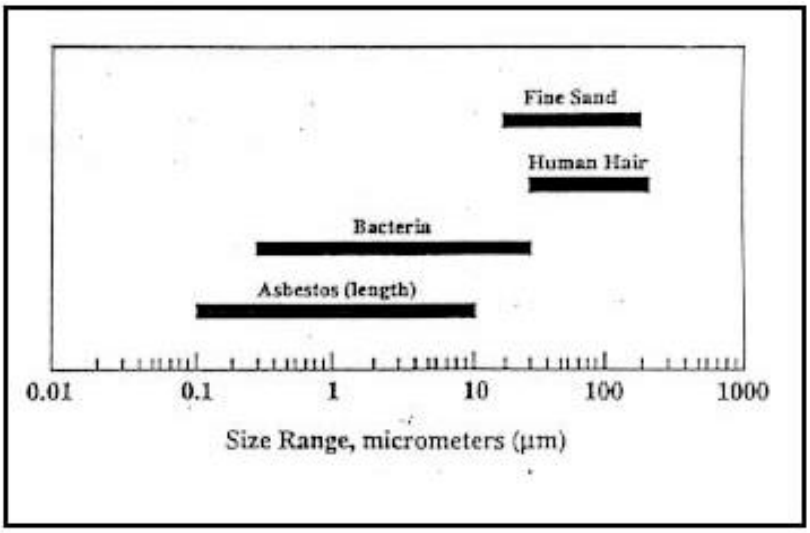

Figure 1-2. Asbestos Fiber Size Comparison.
Adapted from *Asbestos-Containing Materials in School Buildings. A Guidance Document (Part 2), EPA 450/2-78-014, March 1978.*

Federal Regulatory Agencies

Several federal agencies have regulatory authority over asbestos. Figure 1-3 lists the most active federal agencies in asbestos regulatory control.

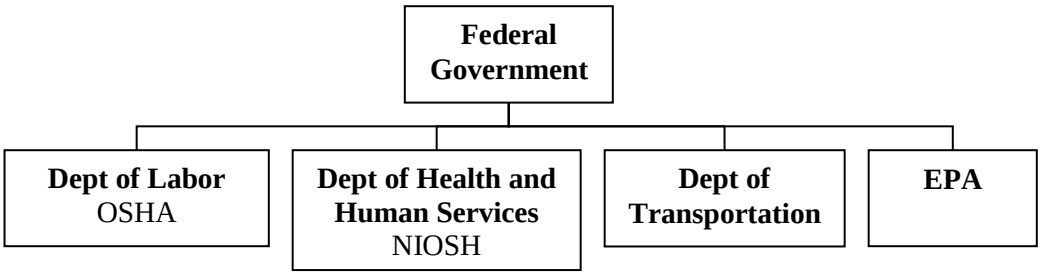

Figure 1-3.

The roles of these federal agencies that regulate asbestos are discussed below.

Department of Labor

OSHA, an agency within the U.S. Department of Labor, has published several asbestos standards designed to protect employees at their worksites: *Shipyard Employment Asbestos Standard* (29 CFR 1915.1001), *General Industry Asbestos Standard* (29 CFR 1910.1001) and *Construction Asbestos Standard* (29 CFR 1926.1101).

Department of Health and Human Services

The National Institute of Occupational Safety and Health (NIOSH), an agency within the U.S. Department of Health and Human Services (DHHS) tests respirators and acts as the research arm of OSHA. NIOSH also issues industrial hygiene testing protocols such as the NIOSH Method 7400, used in counting fibers in air samples by the PCM method.

Department of Transportation

The U.S. Department of Transportation regulates the transport of commercial asbestos and asbestos waste and dictates the labeling of waste bags and marking of transport vehicles.

Environmental Protection Agency

EPA regulates asbestos under the authority of several federal statutes including the Clean Air Act (CAA); the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA); the Resource Conservation and Recovery Act (RCRA); the Safe Drinking Water Act (SDWA); and the Toxic Substances Control Act (TSCA). These regulations help protect citizens from the harmful effects of asbestos. (See Figure 1-4.)

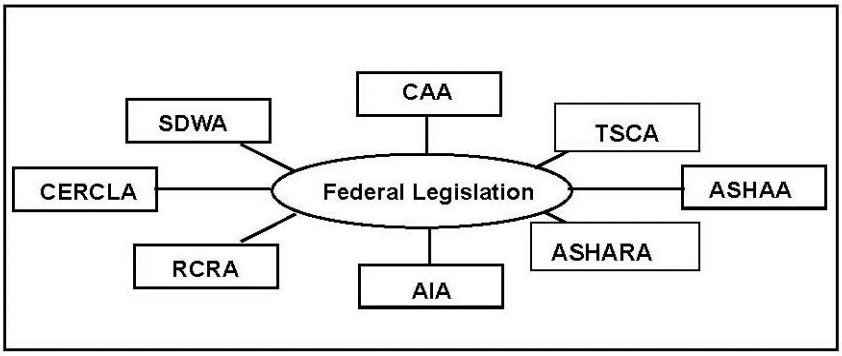

Figure 1-4.

In order to reduce potential exposure to asbestos, numerous regulations have been developed by federal, state and local governments. Only federal asbestos regulations will be discussed in this manual due to the impracticality of describing the full range of widely varying state and local regulations. Inspectors should, however, gain a good working knowledge of their own agency's asbestos regulations since state and local regulations may have more specificity than the companion federal regulations.

Laws and Regulations Addressing Asbestos Control

Several federal laws and regulations establish regulatory programs for asbestos control. They are summarized in this section.

Clean Air Act (42 USC 7401, et seq.)

The Clean Air Act (CAA) was signed into law in 1970 and has been the basis for many federal regulations to address air quality concerns. Regulations developed pursuant to the CAA include National Emissions Standards for Hazardous Air Pollutants (NESHAPs) which are designed to regulate substances for which no ambient air quality standard is applicable and which may cause or contribute to an increase in mortality or an increase in severe irreversible, or incapacitating reversible illness. The NESHAPs program has relied upon Section 112 of the CAA for many elements, compounds and emissions categories including arsenic, asbestos, benzene, beryllium, coke oven emissions, mercury, perchloroethylene, radionuclides and vinyl chloride. The hierarchy for asbestos NESHAP regulations is illustrated in Figure 1-5.

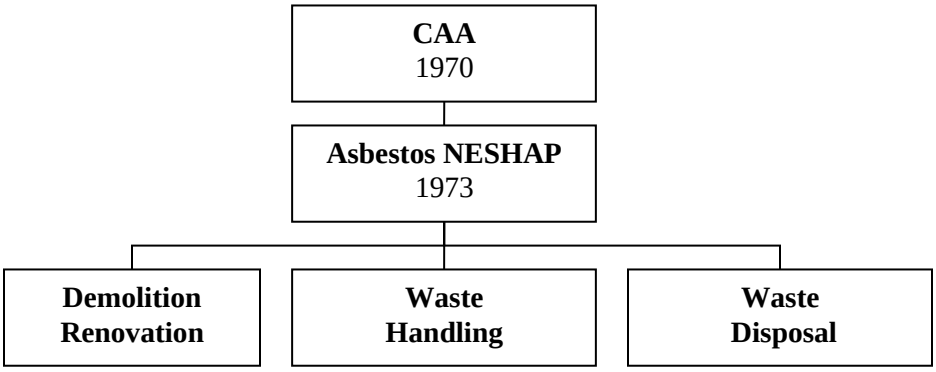

Figure 1-5.

The asbestos NESHAP, found at 40 CFR Part 61 Subpart M, was first promulgated in 1973. Its purpose is to protect the public from exposure to asbestos in the ambient air. Discussions of the asbestos NESHAP program in this manual will focus on demolition and renovation of buildings containing asbestos building materials, handling and managing of asbestos-containing waste material (ACWM) and subsequent waste disposal. The asbestos NESHAP also regulates manufacturing and fabricating operations, spray application of asbestos, waste disposal for asbestos mills and inactive waste disposal sites and establishes standards for asbestos mills and roadways. The asbestos NESHAP also has a provision regarding approval of a conversion process.

The demolition/renovation provisions of the asbestos NESHAP are broken down into five basic categories (see Figure 1-6) that will be discussed in more detail in this manual.

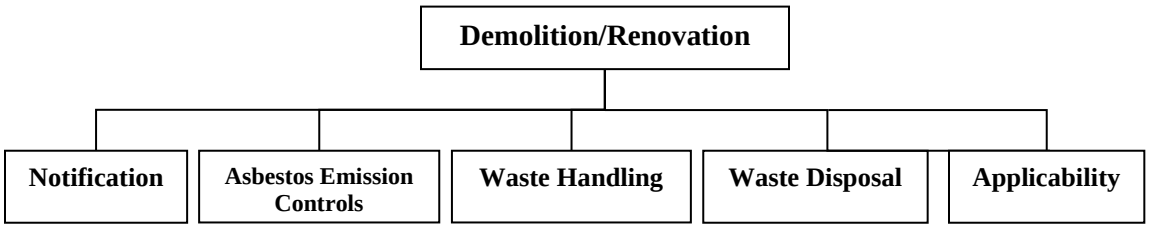

Figure 1-6.

Toxic Substances Control Act (TSCA) (15 USC 2601, et seq.)

The *Toxic Substances Control Act* (TSCA) was signed into law in 1976 and permits EPA to identify and evaluate potential hazards from chemical substances. It also allows EPA to regulate the production, use, distribution and disposal of such substances. Several regulations, discussed below, have been issued under the authority of TSCA. Copies of the various TSCA regulations and Federal Notices may be obtained via www.gpo.gov or by calling the TSCA Hotline at 202-554-1404.

The TSCA statute and legislation are outlined in Figure 1-7.

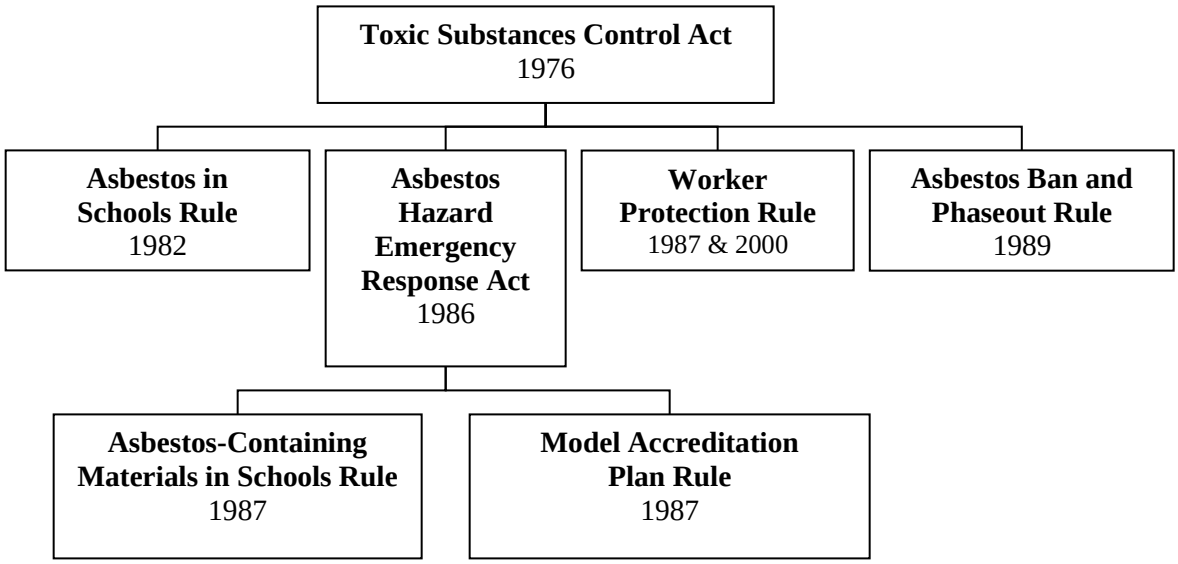

Figure 1-7.

Asbestos in Schools (AIS) Rule (40 CFR Part 763 Subpart F)

The original *Asbestos in Schools* (AIS) *Rule*, promulgated in 1982, set up requirements for inspection of public and private schools having grades K-12 (as defined in the *Elementary and Secondary Education Act)* for friable suspect asbestos-containing material (ACM). (See Figure 1-8.)

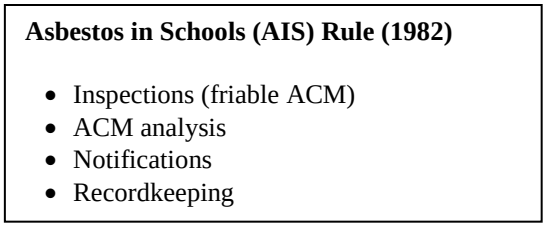

Figure 1-8.

The AIS rule required the collection of samples and subsequent analysis of such material to determine if asbestos was present. It also required the schools to provide notification to school workers and parents concerning the presence of asbestos, to post warning signs if friable ACM were found and to maintain records accessible to the public regarding the inspections. There were neither requirements for abatement nor provisions for funding. The AIS Rule did provide guidance for abatement (i.e., removal, encapsulation, enclosure, or maintenance programs). The requirements of this regulation were to have been met by June 1983.

Asbestos Hazard Emergency Response Act (AHERA) (15 USC 2641)

In order to improve upon the 1982 AIS Rule, in 1986 Congress passed the *Asbestos Hazard Emergency Response Act* (AHERA) which was added as an amendment *(Title II Asbestos Hazard Emergency Response)* to TSCA and required both EPA and the states to address asbestos hazards which might exist in schools. (See Figure 1-9.)

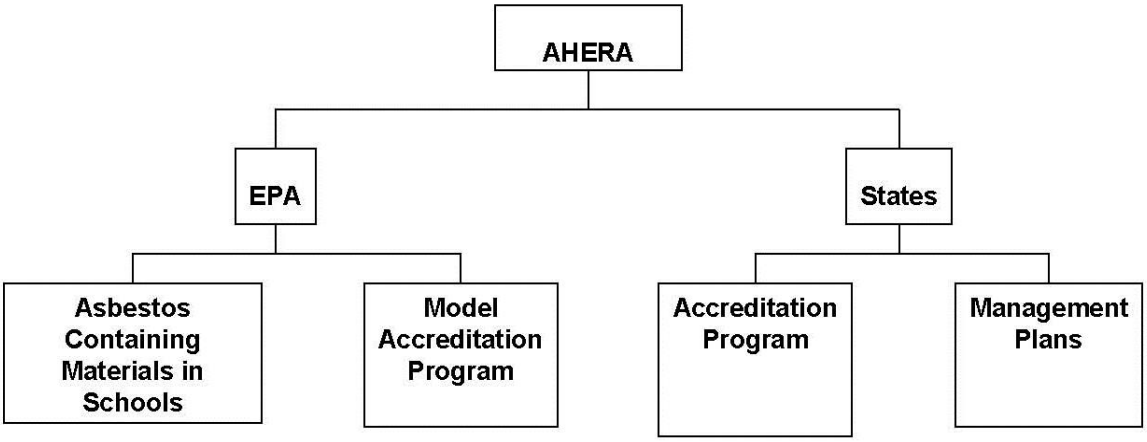

Figure 1-9.

EPA was required to promulgate rules regarding asbestos-containing materials in schools and to develop a model accreditation plan for persons who inspect for asbestos, develop management plans and design or conduct response actions. States were required to adopt an accreditation program at least as stringent as the EPA model and to review management plans submitted by school systems.

Asbestos-Containing Materials in Schools Rule (40 CFR Part 763 Subpart E)

In 1987, in response to the AHERA mandate, EPA published its *Asbestos-Containing Materials (ACM) in Schools Rule* which required public and private schools having grades K-12 to be inspected for the presence of friable and nonfriable asbestos-containing building materials (ACBM) and that determinations be made of ACBM conditions and hazards. (See Figure 1-10.) Based on the inspections, the schools were also required to develop and implement management plans, conduct response actions in a timely fashion and reinspect schools every three years.

ACM in Schools (1987)

- Inspections
- Management Plans
- Response Actions
- Re-inspections

Figure 1-10.

Model Accreditation Plan (MAP) (40 CFR Part 763 Subpart E Appendix C)

In 1987, also in response to the AHERA mandate, EPA published its *Model Accreditation Plan* (MAP) which established initial and refresher training requirements for inspectors, management planners, abatement project designers, asbestos abatement contractors/supervisors and asbestos abatement workers. (See Figure 1-11.)

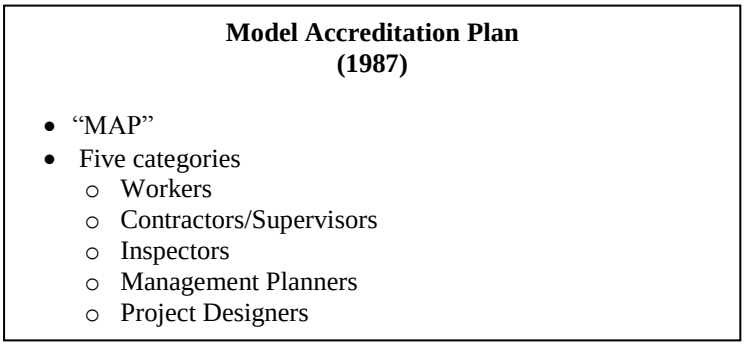

Figure 1-11.

The MAP also included information regarding qualifications, examinations, decertification requirements and reciprocity.

In 1990, the *Asbestos School Hazard Abatement Reauthorization Act* (ASHARA) mandated revisions to the original MAP. On February 3, 1994, EPA published its *Asbestos Model Accreditation Plan; Interim Final Rule* (59 FR 5236), which replaces the original MAP. (See Figure 1-12.)

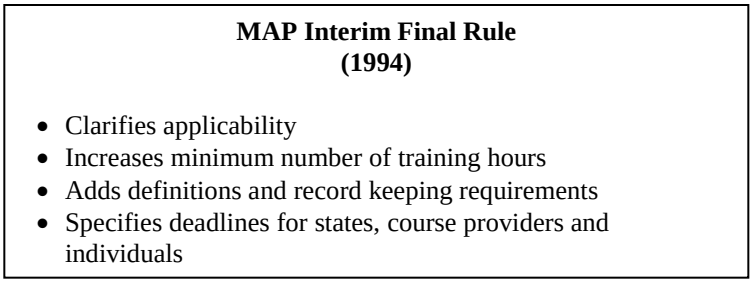

Figure 1-12.

The revised rule, effective April 4, 1994, clarifies the types of persons who must be accredited to work with asbestos in schools and public and commercial buildings; increases the minimum number of hours of training, including additional hours of hands-on health and safety training for asbestos abatement workers and contractor/supervisors; and effects a variety of other necessary changes as mandated by ASHARA.

The revised MAP added new components to the original MAP: (1) definitions which help to determine the scope and applicability of the rule and (2) new record keeping requirements for the providers of accredited training courses. The changes also specify the deadline for states to modify their accreditation programs to be no less stringent than

the revised MAP and prescribe deadlines for training course providers and persons who must obtain accreditation to comply with new requirements.

The revised MAP also distinguishes between the training requirements for each of the five accredited training disciplines; adds several new topics to the project designer training curriculum; establishes new enforcement criteria and federal procedures for withdrawing approval from accredited persons and training programs; and stipulates new information requirements for training certificates. (See Figure 1-13.)

Additional MAP Components

- Training requirement distinctions for five training disciplines.
- New project designer topics.
- New enforcement criteria and federal procedures for withdrawing approval (persons/programs).
- New training certificate information.

Figure 1-13.

The organization and some of the language of the original MAP have also been changed, but these modifications are only technical and do not impose new substantive requirements.

Worker Protection Rule (WPR) (40 CFR Part 763 Subpart G)

EPA published the *Worker Protection Rule* (WPR) in 1987 and amended it in 2000. (See Figure 1-14.)

Worker Protection Rule
(2000)

- "WPR"
- State/local government employees
- OSHA Construction/General Industry Standards
- Construction, custodial, automotive brake/clutch repair

Figure 1-14.

This rule extends the asbestos standards of OSHA (29 CFR 1926.1001 and 29 CFR 1926.1101) to state and local government employees who perform construction work, custodial work and automotive brake and clutch repair work. The WPR cross-references the OSHA asbestos standards so that future amendments to these standards will be directly and equally effective for employees covered by the WPR. In states having their own OSHA programs, state and local government employees may be covered by such programs.

Asbestos Ban and Phaseout Rule (ABPO) (40 CFR Part 763 Subpart I)

In 1989 EPA published the *Asbestos Ban and Phaseout Rule* (ABPO) which prohibited, at staged intervals, the future manufacture, importation, processing and distribution in commerce of almost all asbestos-containing products. (See Figure 1-15.)

Asbestos Ban and Phaseout Rule
(1989)

- "ABPO"
- 3 stages
- Manufacture, import, processing ban
- Distribution in commerce ban

Figure 1-15.

EPA's objective was to reduce unreasonable health risks to the public by eliminating certain asbestos-containing products and replacing them with safer alternatives.

In October 1991, the U.S. Court of Appeals for the Fifth Circuit overturned EPA's ban, arguing that the Agency failed to consider less burdensome alternatives than an outright ban.

In November 1991, in response to a request by EPA for clarification of the overturning of the ABPO, the U.S. Court of Appeals stated that EPA could ban new uses of asbestos and products that were not on the market on July 12, 1989, the effective date of the ABPO rule.

EPA, via the asbestos NESHAP and the Consumer Product Safety Commission (CPSC) published bans on major categories of ACM in the 1970s. (See Table 1-2.)

Table 1-2. ACM bans in the 1970s.
1973 Asbestos NESHAP: Spray- and trowel-applied fireproofing
1975 Asbestos NESHAP: Wet-applied and preformed pipe, boiler and tank insulation
1977 CPSC: Wallboard patching compounds (spackling, tape) and asbestos embers
1978 Asbestos NESHAP: Decorative materials

EPA subsequently clarified the provisions of the ABPO in the Federal Register (58 FR 58964, November 5, 1993). (See Table 1-3.)

Table 1-3. ACM Additionally Banned by ABPO.
Corrugated paper
Rollboard
Commercial paper
Specialty paper
Flooring felt
New uses of asbestos

A wide variety of asbestos-containing products are still available and legally in use today. In addition, many products, although banned by EPA and CPSC, were imported and installed, often without knowledge of suppliers or installers. (See Table 1-4.)

Table 1-4. Asbestos-Containing Products Remaining in Use.		
Automatic transmission components	Clutch facings	Pipeline wrap
Brake blocks	Friction materials including disk brake pads, drums, linings	Roofing and non-roofing coatings
Cement corrugated sheets, flat sheets, shingles and pipe	Gaskets	Roofing felt
Clothing	Millboard	Vinyl floor tile

Table 1-4 is not all-inclusive. A wide variety of products are still available and legally in use today. In addition, many products, although banned by EPA and CPSC, were imported and installed, often without knowledge of suppliers or installers.

Asbestos School Hazard Abatement Act (ASHAA) (20 USC 4011)

In 1984 the *Asbestos School Hazard Abatement Act* (ASHAA) was written to provide a source of special funding for the Asbestos in Schools Program. (See Figure 1-16.)

Asbestos School Hazard Abatement Act (1984)

- "ASHAA"
- Grants and loans
- Information distribution
- Training institutes

Figure 1-16.

The Act provided a $600 million grant and loan program to assist financially needy schools with asbestos abatement projects. ASHAA also provided for compilation and distribution of information concerning asbestos and funded the start-up of training institutions. The original recipients of training funding were Tufts University (MA), the Georgia Tech Research Institute and the University of Kansas.

Asbestos School Hazard Abatement Reauthorization Act (ASHARA) (20 USC 4011)

The *Asbestos School Hazard Abatement Reauthorization Act* (ASHARA), signed into law in 1990, reauthorized funding for schools in need and mandated revisions to EPA's Model Accreditation Plan (MAP) developed under AHERA. (See Figure 1-17.)

Asbestos School Hazard Abatement Reauthorization Act (1990)

- "ASHARA"
- Grants and Loans
- MAP Revisions

Figure 1-17.

ASHARA required EPA to increase the minimum number of training hours required for asbestos abatement workers and extend accreditation requirements to include persons who inspect for ACM or who design or conduct response actions with respect to friable ACM in public and commercial buildings. In addition, ASHARA authorized EPA to modify the MAP as necessary to implement the extension of accreditation requirements to public and commercial buildings and amended penalty provisions of TSCA Section 207 (15 USC 2647).

Asbestos Information Act (AIA) (Public Law 100-577)

The *Asbestos Information Act* (AIA) was signed into law in October 1988. (See Figure 1-18.)

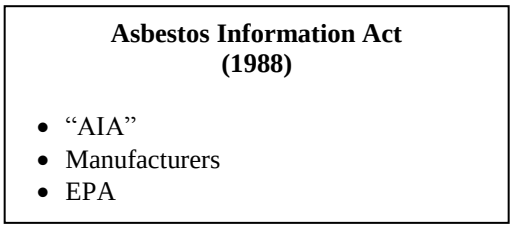

Figure 1-18.

The AIA required former and current manufacturers and processors of certain asbestos products to submit information identifying their products to EPA and required EPA to organize and publish the submitted information. On February 13, 1990, EPA published a summary of the information submitted by 38 companies (55 FR 5144).

Resource Conservation and Recovery Act (RCRA) (42 USC 6901, et seq.)

The *Resource Conservation and Recovery Act* (RCRA) was enacted in 1976 to regulate the management of hazardous waste, to ensure the safe disposal of wastes and to provide for resource recovery from the environment by controlling hazardous wastes "from cradle to grave." (See Figure 1-19.)

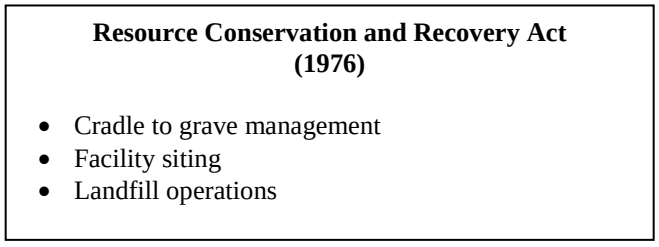

Figure 1-19.

In 1976, asbestos became regulated as a hazardous substance under RCRA. It was de-listed that same year because its classification as a RCRA waste was deemed inappropriate. Asbestos, unlike other substances regulated by RCRA, does not migrate appreciably in soils nor does it pose any threat to ground water. RCRA Subtitle D currently regulates asbestos waste disposal only in a general way, through facility siting and general landfill operation requirements.

Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) (42 USC 9601, et seq.)

The *Comprehensive Environmental Response, Compensation and Liability Act* (CERCLA) was passed into law in 1980 to address problems associated with the actual or potential release of hazardous substances into the environment. (See Figure 1-20.)

Comprehensive Environmental Response, Compensation and Liability Act (1980)

- "CERCLA" or "Superfund"
- Reportable Quantity = 1 pound asbestos
- National Response Center

Figure 1-20.

Under CERCLA, reportable quantities (RQs) have been established for a number of hazardous materials. The RQ for asbestos is one pound. Should a release or threat of release of at least one pound of asbestos occur, the National Response Center must be informed immediately at 800-424-8802. Noncompliance with the provisions of CERCLA may result in administrative enforcement or prosecution for a felony offense. Penalties may include the assessment of heavy fines and imprisonment for more serious offenses. CERCLA is often referred to as "Superfund" because its authority was clarified in the 1986 *Superfund Amendments Reauthorization Act* (SARA).

Safe Drinking Water Act (SDWA) (42 USC 300)

The Safe Drinking Water Act (SDWA) was enacted in 1974 in order to assure that all people served by public water systems would be provided with a supply of high-quality water. (See Figure 1-21.)

Safe Drinking Water Act (1974)

- "SDWA"
- Digestive tract cancers
- 7×10^6 fibers (>10 mm in length) per liter

Figure 1-21.

The Act established a program to require compliance with national drinking water standards for contaminants that may have an adverse effect on public health. The Act also focused on the removal of contaminants found in water supplies and established programs intended to protect underground sources of drinking water from contamination.

During the early 1980s, EPA's Office of Drinking Water (ODW) closely examined the issue of potential health hazards associated with ingestion of asbestos fibers. The ODW reviewed numerous human and laboratory animal epidemiological studies and, despite the uncertainty of research conclusions linking an increased risk of development of digestive tract cancers to exposure to asbestos fibers, proposed to establish an asbestos fiber limit in drinking water.

The 1986 SDWA Amendments required EPA to regulate asbestos as a contaminant of drinking water. In 1991 a limit of seven million asbestos fibers (greater than 10 mm in length) per liter of drinking water was established in the *National Primary Drinking Water Regulations.*