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ASBESTOS REMOVAL IN THE CONSTRUCTION INDUSTRY

BY

ALBERT J. BANKS JR.

A REPORT PRESENTED TO THE GRADUATE COMMITTEE
OF THE DEPARTMENT OF CIVIL ENGINEERING IN
PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF MASTER OF ENGINEERING

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To my mother for her inspiration, and my family for their support they have provided throughout my career. I give special thanks to my wife Claudia for her patience and understanding.

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TABLE OF CONTENTS

CHAPTER ONE
WHY ASBESTOS?

1.1 Introduction

The purpose of this report is to examine the impact of asbestos abatement on the construction industry. The 43 asbestos abatement firms on ENR's Top 600 Specialty Contractors reported revenues of nearly $650 million in 1989 (1-64). The market will continue to grow due to the numerous uses of asbestos in building materials in the past and the health impact on both the occupants and workers. It is estimated that the cleanup effort may cost $100 billion over the next twenty five years. More than 733,000 structures, or twenty percent of U. S. commercial and public properties are believed to contain asbestos, according to the Environmental Protection Agency (EPA). In about two thirds of the buildings with asbestos, some of the material is in a friable state. This asbestos is crumbling into microscopic fibers that can float in through the air. The Environmental Protection Agency in 1973, severely restricted the use of asbestos after high doses of its fibers were found to scar the lungs, causing cancer and other diseases (2-53).

Construction businesses use 50 percent (1984 figures) of the U. S. supply of asbestos in asbestos-cement pipes, sheets, siding shingles, floor tiles, coating, and sealants. Some 29,000 workers install asbestos insulation during building construction. Other estimates of exposed workers include

20,400 in demolition, 67,800 in abatement, 82,500 in general building renovation, 135,700 doing routine maintenance in commercial and residential buildings, and 183,200 in routine maintenance in general industry (3-3).

The demand for asbestos removal services exceeds the ability of the industry to supply it safely. The industry has grown from an estimated $200 million in 1983 to more than $2.7 billion in 1988. This rapid growth of the fledgling industry has produced some less than reputable contractors. They spring up overnight and disappear a few months later. The result has been increased regulation on the local, state and federal level. States have created training and certification programs. The EPA has expanded the Asbestos Hazard Emergency Response Act (AHERA) to commercial and public buildings. Real estate professionals believe that asbestos cleanup cost will burden them for the next two decades, and are lobbying for tax credits (4-53). Asbestos management and removal are big business. It is a major issue for the construction industry world wide.

CHAPTER TWO
WHAT IS ASBESTOS?

2.1 Introduction

The name asbestos is derived from the Greek work "asbennynai" meaning unquenchable. Asbestos is the common name given to several naturally occurring mineral silicates. These silicates possess a crystalline structure which are incombustible in air and separate into filaments. The type of asbestos used in a manufactured product cannot be identified by color. The natural colors tend to change through the action of heat. The presences of asbestos may be concealed by finishing cements, coatings, paint, or cladding. To determine the presence and type of asbestos used, the bulk sample must be examined by microscopy.

Asbestos is widely used as it is a relatively inexpensive, virtually indestructible material with special chemical and physical properties. Its primary desirable physical properties include chemical resistance, bacterial resistance, incombustibility, thermal insulating ability, electrical insulating ability, mechanical strength, high length-to-diameter ratio, flexibility, and good friction and wear characteristics. Properties important in the industrial fabrication of asbestos composite materials include wet strength, ease of formation of slurries with water, and good drying characteristics. Filtration and acoustical components from asbestos containing material (ACM) are indirect industrial applications.

The four main types of asbestos are:

1. Chrysolite or white asbestos. This is a fine silky flexible white fiber. It is mined mainly in Canada, Russia, and Rhodesia. It is the most abundant of the asbestos minerals, and makes up 90 percent of the total world production. Having the foremost combination of strength and flexibility it can be easily woven, thus producing asbestos cloth, heat insulation, and protective clothing. This form of asbestos has very good heat resistance, but can be destroyed by acid.

2. Amosite. This is a straight brittle light grey to pale brown fiber mined in South Africa. The most important features are its heat and corrosive resistance properties, the elasticity of the fibers, and the high bulk density volume when separated by processing. It is used most widely for heat insulation applications, e.g., fire-resistant insulation board.

3. Crocidolite or blue asbestos. This is a straight needle-like blue fiber. It is found in South Africa, Western Australia, and Bolivia. It is the strongest of the asbestos fibers. The high mechanical strength combined with its acid resistance makes it a valuable industrial material. It does, however, tend to fuse at high temperatures. It is used

largely in the manufacture of asbestos-cement pipes and marine insulation aboard ships.

4. Anthophyllite. This is a brittle white fiber mined in Finland and Africa. A rare fibrous material, its resistance to heat is good and acid resistance properties are excellent. It is used as an expensive filler and in specialized applications.

Other types of asbestos include tremolite and actinolite. All forms of asbestos are chemically different and have different properties and applications.

2.2 History of asbestos use.

Asbestos has been used since prehistoric times. Pottery containing asbestos fibers dating from 2500 BC have been found in Finland. Finnish peasants used the material in insulating their huts. In 456 BC, Heroditus refers to asbestos as a cloth for retaining the ashes of the dead after cremation. The ancient Greeks used asbestos in wick making and weaving of cloth because of its fire-resistent properties. The fiber was used in French armor in the fifteenth century. It was first used in paper manufacture in Norway in the eighteenth century. Benjamin Franklin mentions in his diary from London the weaving of asbestos purses. During the second half of the nineteenth century, asbestos was used widely in several European states in paper making. The versatility of the fiber was fully exploited at the end of the nineteenth century, with the revolution in manufacturing in western Europe and North America (5-8).

Asbestos was first mined in the Quebec chrysotile fields in 1887, followed by Russia in 1885 and South Africa in 1906. Its use grew slowly. The production of asbestos for 1976 alone exceeded the 1930 cumulative total. Two thirds of the 3000 recorded uses of asbestos are in the construction industry. Applications include: asbestos cement sheet pipe, flooring and roofing products, electrical and thermal insulation materials, friction products, coatings, compounds, and textiles. In most asbestos products the fibers are bound in a matrix or are encapsulated and do not contribute a health risk in these states. Potential health risks arise during the drilling, sawing, nailing, demolition, etc. of asbestos products. These activities can result in the release of free asbestos fibers to the air. These free airborne fibers can affect people other than the workers directly concerned.

The public health hazards associated with asbestos came to light within twenty years of the first factory production of asbestos. Sixteen out of seventeen workers in a French asbestos weaving factory died between 1890 and 1395. By 1899 eleven men who had worked in an asbestos spinning factory died at the age of about 30. They had spent their whole working lives at the factory. The first recorded case of the disease to become known as asbestosis was reported by Dr. Montague Murray in 1906.

The first complete description of asbestosis appeared in 1927. Asbestosis is a disease resulting from the inhalation of very small particles of asbestos dust, which are deposited in the lungs. This causes the formation of scar tissue (fibrosis) resulting in fatigue and breathlessness after some years. Other diseases associated with exposure to asbestos dust are mesothelioma and lung cancer. Mesothelioma is a cancer of the membrane lining of the chest or abdomen. It is almost exclusively associate with asbestos exposure and may have a long latent period. About 50% of asbestosis sufferers develop lung cancer. The probability of this happening is significantly increased if the person is also a cigarette smoker (6-2).

Asbestosis is associated with long term, high exposure to airborne asbestos. Symptoms rarely become apparent until at least ten years of exposure. It is an irreversible process with no effective treatment. It is a progressive disease that has various degrees of severity. The risk of asbestosis rises with increasing asbestos exposure. The exposure can continue to cause damage to the lungs even after direct exposure has ceased. Low level non-occupational exposures have not been shown to cause the advanced stages of asbestosis, but early mild stages may occur. In advanced stages, asbestosis can be fatal. In a study of 17,800 asbestos insulation workers exposed to asbestos throughout their working life, the cause of death was asbestosis in 1246 or 7% (7-56).

2.3 Asbestos-Containing Materials (ACM) in Buildings

The widespread commercial use of asbestos over the past 100 years has led to its uncontrolled distribution throughout much of the industrialized world. Construction materials containing asbestos have been used extensively in buildings and structures. The concern about exposure to asbestos in these buildings is based on the various respiratory diseases linked with the occupational exposure in the shipbuilding and fabricating industries. The presence of asbestos in a building may not endanger the health of building occupants. If asbestos-containing material (ACM) remains in good condition and is not disturbed, exposure should be negligible. When ACM is damaged or disturbed, by maintenance or repairs conducted without proper controls, asbestos fibers are released. These fibers create a potential hazard for building occupants.

ACM has been grouped into three categories: (1) sprayed or troweled on materials on ceilings, walls, and other surfaces, (2) insulation on pipes, boilers, tanks, ducts, and other equipment, and (3) other miscellaneous products. A general list of ACM are shown in Table 1, a detailed list is included as Appendix A. Material in the first two categories can be friable, while most ACM in the third category is not friable. Although non-friable ACM is of less immediate concern, it can not be ignored. Fibers will be released in non-friable material which is cut, drilled, sanded, or broken during building repairs or renovation (8-1).

2.4 Asbestos Regulations.

Building owners and contractors are governed by a variety of federal, state, and local regulations regarding how they handle ACM within their facilities. There are several Occupational Safety and Health Administration (OSHA) and EPA regulations designed to protect the workers. OSHA has specific requirements for worker protection and procedures to control ACM. These include the OSHA construction industry standard for asbestos (29 CFR 1926.58), the OSHA general industry asbestos standard (29 CFR 1910.1001), and the EPA National Emission Standards for Hazardous Air Pollutants; Asbestos NESHAP Revision; Final Rule (40 CFR Part 61, issued November 20, 1990). State delegated OSHA plans and local jurisdictions may impose additional requirements. Prudent owners and contractors should contact the appropriate organizations if there is any questions.

Table 1-1 Asbestos Containing Building Products.

Building Product	Approximate Content (%)	Type Asbestos
Asbestos cement building products (except pipes)	12-15	Chrysotile
Fire resistant insulation boards	25-40	Amosite
Asbestos paper	70-95	Chrysotile
Asbestos millboard	45-98	Chrysolite
Asbestos insulation blocks and pipe sections	55	Amosite
Asbestos reinforced thermosetting plastics	55	Chrysotile
Asbestos jointing and packings	25-85	Chrysotile
Asbestos textiles	85-100	Chrysotile
Vinyl/asbestos floor tiles	5-7.5	
Chrysotile		

Note: Based on building products manufactured in U. K., (9-308).

2.4.1 OSHA Regulations

The OSHA standards cover private sector workers, and public sector employees in states which have an OSHA state plan. Public sector employees not subject to a state OSHA plan are covered by the EPA "Worker Protection Rule" (40 CFR 763 Subpart G, Asbestos Abatement Projects; Worker Protection, Final Rule). These regulations require employers to address several items when triggered by exposure of employees to asbestos fibers. Exposure is defined in fibers per cubic centimeter (cc) of air (f/cc).

The two main provisions of the regulations are in the general category of "Permissible Exposure Limits (PELs)" to airborne asbestos fibers. They are:

1. 8-Hour Time Weighted Average limit (TWA) - 0.2 f/cc of air based on an 8 hour time weighted average sampling period. This is the maximum level of airborne asbestos , on average, that any employee may be exposed to in an eight hour period.

2. Excursion limit (EL) - 1.0 f/cc as averaged over a sampling period of 30 minutes.

Mandatory requirements are triggered at these asbestos exposure levels. These include: use of respirators and protective clothing, establishment of regulated areas, posting of danger sings, use of engineering controls and specific work practices. OSHA regulations establish an "Action level" of 0.1 f/cc for an 8 hour TWA. Employee training is required once exposure at the action level and/or the excursion limit is reached. Training topics are specified by the OSHA rules. Exposure of an employee at or above the action level for 30 days or more in a calendar year requires medical surveillance. OSHA also requires medical examinations for any employee exposed at the action level and/or excursion limit.

The OSHA Construction Industry Standard (29 CFR 1926.58) for asbestos applies to all forms of asbestos work. This includes Operation and Maintenance (O&M) programs for ACM, demolition and removal, encapsulation projects. Repair, maintenance, alteration, or renovation work involving ACM are covered by this standard. ACM spills or emergency clean up actions are also included.

2.4.2 EPA Regulations

EPA's rules concerning the application, removal, disposal, manufacturing, spraying, and fabrication of ACM were issued under the asbestos NESHAP (National Emission Standards for Hazardous Air Pollutants). This regulation governs asbestos demolition and renovation projects in all facilities. Owners are usually required to remove all friable ACM before a building is demolished, and may require removal before a renovation. When friable ACM will be disturbed during a renovation project appropriate work practices and procedure for the control of emissions may be required. Any ACM which may become friable poses a potential hazard.

In October 1987, EPA issued final regulations to carry out the Asbestos Hazard Emergency Response Act of 1986 (AHERA). This regulation deals only with public and private elementary and secondary school buildings. The schools are required to conduct inspections, develop comprehensive asbestos management plans, and select asbestos response actions to deal with asbestos hazards. A key element of AHERA requires the schools to develop an O&M program if friable ACM or non-friable ACM, which is about to become friable, is present. The regulation's O&M requirements mandate that schools employ specific work practices including wet wiping, HEPA vacuuming, and proper waste disposal procedures. Specific training is required for custodial and maintenance employees who work in buildings with ACM (10-27).

The EPA promulgated in July 1989 an Asbestos Ban and Phaseout Rule (40 CFR 763 Subpart I), under the Toxic Substances Control Act (TSCA). The rule phases out asbestos containing products in three stages.

Phase 1. Bans the production and importing of flooring and roofing felts, vinyl-asbestos tile, asbestos clothing, and asbestos cement flat and corrugated sheets. The ban went into effect August 27, 1990, and commercial distribution of the materials must cease by August 25, 1992.

Phase 2. The ban will affect the automobile brakes and other automobile friction products installed as original equipment. Asbestos containing products will be banned after August 25, 1993, and commercial distribution must end by August 25, 1994. The ban will take effect for new cars introduced in the model year 1994.

Phase 3. Bans asbestos cement pipes and shingles, commercial and corrugate paper, rollboard, millboard, specialty paper, and coatings containing asbestos. It will also cover replacement auto brakes. Production must stop by August 26, 1996, and distribution must end by August 25, 1997 (11-3).

2.5 Asbestos Hazard Management

Contractors and building owners must manage the risks of asbestos exposure to workers and occupants. Building owners can control the asbestos hazard by following these steps: (1) survey property for asbestos, (2) establish an Operations and Maintenance (O&M) program, (3) assess the ACM to determine needed corrective action, and (4) conduct abatement actions as required. Contractors should use established engineering controls and specific work practices to minimize the risk of exposure.

Corrective action alternatives fall into four main categories: removal, encapsulation, enclosure, and deferred action. The first three categories are methods to remove the hazard or greatly reduce the potential risk of exposure. The last category, deferred action is used should the exposure risk be considered negligible (12-269). Corrective action alternatives will be discussed in more detail in later chapters.

CHAPTER THREE
ABATEMENT METHODS

3.1 Introduction

There are three separate and distinct asbestos abatement methods: removal, encapsulation, and enclosure. The method used will depend on the type and location of ACM, worker protection requirements, work area containment, and the rigorous post-abatement cleanup.

3.2 Methods

3.2.1 Removal

The ACM is treated with a water and wetting agent solution to minimize fiber release. If the material will not absorb the wetting agent, a dry removal using Type C respiratory protection is appropriate. EPA must approve all dry removal operations. Friable ACM must be disposed in leak tight containers, typically 6 mil polyethylene bags. Bags can be placed in 55 gallon drums for additional protection. Bags and drums must be labeled as specified by NESHAP or OSHA. Procedures for worker protection and decontamination must be strictly follow OSHA guidance. Airborne asbestos must be measured. EPA work area containment procedures must be followed for a safe removal and disposal.

3.2.2 Encapsulation

Encapsulation is the spaying of ACM with a sealant. This may be a penetrant, which penetrates and hardens the asbestos material; or a bridging encapsulant, which covers the surface of the material with a protective coating. Both types of sealants are applied using airless spray equipment at low pressure. This is done to reduce fiber release during application.

Encapsulation should use only granular, cementitious material. Material that is delaminated or deteriorated should not be encapsulated. The material will be pulled down by the additional weight if its delaminated. Deteriorated ACM may be blown off by sealant application. EPA has evaluated over 100 sealants, using five criteria; impact resistance, flame spread, smoke generation, toxic gas release during combustion, and adhesive strength. This study data is useful in selecting a sealant, but the sealant should be tested on site over several days to determine its effectiveness. The type of sealant and the type of material and substrate encapsulated should be recorded. This information in needed to avoid asbestos fiber release during later remodeling or demolition.

3.2.3 Enclosure

Enclosure involves the construction of airtight walls and ceilings around the ACM. The purpose is install a barrier between the ACM and the building environment. Corrugated metal or PVC installed around ACM insulated piping is an example of an enclosure. A combination of encapsulation and enclosure are often required for maximum protection.

The following are recommendations for constructing enclosures.

Drills equipped with HEPA (High Efficiency Particulate Air) filtered vacuums should be used during installation to reduce fiber release.

It must be ensured that underlying structures are capable of supporting new walls and ceilings.

New construction materials should be impact resistant and assembled to be airtight. Gypsum panels taped at the seams, tongue and groove boards, and boards with spline joints are all acceptable. Suspended ceiling with lay-in panels should not be used. All joints between walls and ceilings should be caulked.

Lights recessed in ACM should be carefully removed to minimize fiber release. Plumbing lines, telephone cables, and computer cables should be relocated as necessary.

Building records should be updated to note the presence of asbestos behind the enclosure to prevent accidental fiber release. These documents should be reviewed before beginning remolding or demolition. Signs noting that ACM is behind the enclosure should be posted. A part of an O&M program is the documentation of ACM in a building.

3.3 Removal Techniques

There are two classifications of work practices and engineering controls for the removal of ACM. They are:

1. Major asbestos removal, renovation, and demolition operations (29 CFR 1926.58, Appendix F); and

2. Small-scale, short duration asbestos renovation and maintenance activities (29 CFR 1926.58, Appendix G).

3.3.1 Major Asbestos Removal

This technique is used to abate recognized asbestos hazard or in preparation for major building renovation or demolition. These projects require the construction of negative pressure temporary enclosures to contain the asbestos and prevent exposure to employees and bystanders at the site. The contractor must provide hygiene facilities to ensure asbestos is not removed from the site on the employees. This is an expensive and time consuming operation.

There are six steps in the major removal process;

(1) The removal project must be planned,

(2) Material and equipment must be procured,

(3) The work area should be prepared,

(4) Removal of the ACM,

(5) Cleaning of the work area,

(6) Disposal of the ACM.

A brief summary of each of the steps is provided. Further details are available in 29 CFR 1926.58, appendix F.

The planning is critical to completing an asbestos removal project safely and cost effectively. Written asbestos removal plans will aid in the reporting requirements of the

EPA regulations, 40 CFR 61, Subpart M. An asbestos abatement plan contains the following information;

- A physical description of the work area,
- A description of the approximate amount of ACM to be removed
- A schedule for turning off and sealing existing ventilation systems,
- Personnel hygiene procedures,
- Labeling procedures,
- A description of personal protective equipment and clothing to be worn by employees,
- A description of the local exhaust ventilation systems to be used,
- A description of work practices to be observed by employees,
- A description of the methods to be used to remove the ACM,
- The wetting agent to be used,
- A description of the sealant to be used at the end of the project
- An air monitoring plan,
- A description of the method to be used to transport waste material,
- The location of the dump site.

Equipment and material requirements vary for each asbestos removal project. The following list of materials and equipment should be available at the beginning of the project: rolls of polyethylene sheeting and grey duct tape, HEPA filtered vacuums and portable ventilation systems, airless sprayer, wetting agent, portable shower unit, appropriate respirators, disposable coveralls, signs and labels, pre-printed disposal bags, and a pressure gauge.

A HEPA filtered vacuum is essential for cleaning the work area after the ACM is removed. These vacuums use a HEPA filter capable of removing 99.97 percent of the asbestos particles from the air.

All movable objects should be removed from the work area before constructing the negative pressure enclosure. When movable objects are contaminated or suspected of being contaminated, they should be vacuumed with a HEPA vacuum and cleaned with amended water. Wiping with plain water is recommended where amended water will damage the object. Wetting agents, surfactants, are added to water which is then called amended water. All objects not moved should be covered with a 6 mil thick polyethylene plastic sheeting before starting asbestos removal work. Duct tape is recommended to achieve an air tight seal around objects. All penetrations of the floor, walls, and ceiling should be sealed with the same plastic sheeting.

A single entrance is used for egress with all other doors and window covered with plastic sheeting and securely taped. A building hygiene facility (decontamination facility) is constructed at the entrance to decontaminate asbestos workers, equipment, and clothing. These facilities consist of: a clean change room, a shower, and an equipment room. The layout of a typical hygiene facility is shown in Figure 1.

A ventilation system should be installed to create a negative pressure within the enclosure with respect to the area outside. The system must be equipped with HEPA filters to prevent the release of asbestos fibers to the outside air. The ventilation system should be operated 24 hours a day during the entire project until the final cleanup is complete and final air samples are received. A negative pressure of 0.02 inches of water should be created within the enclosure with respect to the outside area. The exhaust air should be vented to the clean outside air. A simple negative pressure system is shown in Figure 2.

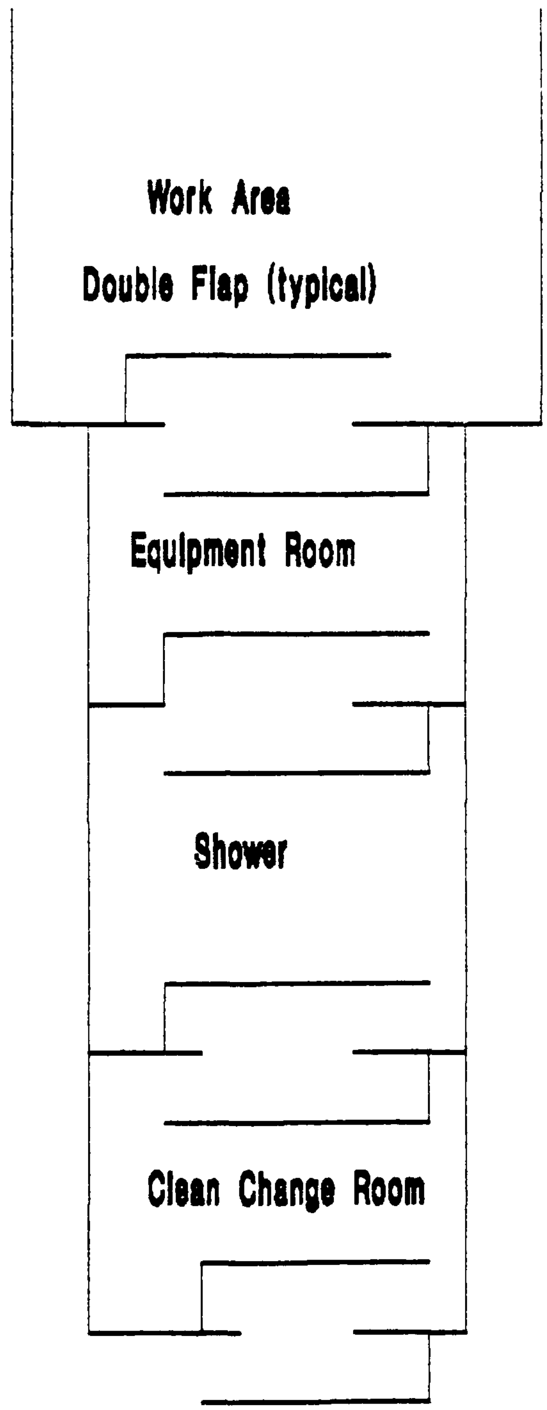

Figure 1. Typical Hygiene Facility Layout.

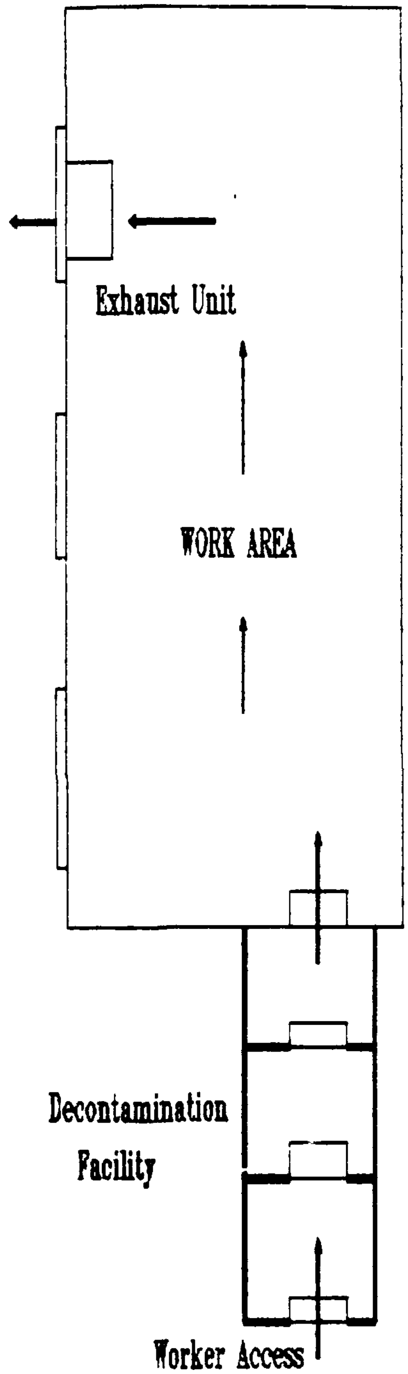

Figure 2. Simple Negative Pressure System.

Regulations require employers involved in asbestos removal, demolition, or renovation operations to designate a competent person to: set up and ensure the integrity of the enclosure, control the entry and exit, supervise all employee exposure monitoring, ensure the use of protective clothing and equipment, ensure that employees are trained in proper procedures, ensure the use of hygiene facilities, and observance of proper decontamination procedures, and ensure that engineering controls are functioning properly. A certified industrial hygienist with training and experience in the handling of asbestos should be the "competent person".

Proper work practices are required during asbestos removal, demolition, and renovation. This will ensure that the concentration of asbestos fibers will be at a minimum within the enclosure. The ACM must be wetted before it is disturbed. After wetting, the material should be removed by scraping or cutting the metal bands that support the ACM on boilers and pipes. Remaining residue should be wire brushed and wet-wiped.

Immediate bagging of asbestos waste material is effective in reducing the airborne asbestos within the enclosure. The asbestos material will generate asbestos dust when disturbed if not bagged upon removal. Contaminated supplies and equipment that cannot be decontaminated should be disposed of in pre-labeled bags. Items in this category include plastic sheeting, disposable work clothes, respirator cartridges, and contaminated wash water.

The entire work area should be cleaned until all visible asbestos dust is removed. All surfaces which had asbestos should be cleaned by wire brushing, HEPA vacuuming the surface, and wiping them with amended water. The inside of the plastic enclosure should be vacuumed with a HEPA vacuum and wet-wiped to remove all visible dust. Final air samples should them be taken at approximately four area samples for each 5000 square feet of enclosure area. The enclosure should not be dismantled unless the final samples are below the final standard's action level. EPA recommends that a clearance level of 0.01 f/cc (fibers per cubic centimeter) be achieved before cleanup is considered complete.

3.3.2 Small-Scale, Short Duration Activities

These removal procedures are described in appendix G, a non-mandatory section, to the OSHA regulation 29 CFR 1926.58. These activities are not precisely defined in terms of size or duration. Small-scale, short duration (SS/SD) renovation and maintenance activities are tasks such as:

Removal of ACM insulation on pipes,

Removal of small quantities of ACM insulation on beams or above ceilings,

Replacement of an ACM gasket on a valve, Installation or removal of a small section of drywall,

Installation of electrical conduits through to ACM.

Employers in the construction industry are expected to use this exception to the final OSHA standards.

The asbestos NESHAP regulation governs asbestos demolition and renovation projects in facilities. The EPA or the designated state authority must be notified before asbestos demolition. This requirement applies if 160 square feet of friable ACM on facility components or 260 linear feet of friable ACM on pipes (quantities involved over a one year period) due to be removed. The notification requirement includes the description of the methods of demolition to reduce exposure to asbestos (13-28).

The following controls and work practices can be used to effectively reduce asbestos exposure during small maintenance and renovation operations:

Wet methods,

Removal methods;

Use of Glove Bags,

Removal of entire asbestos insulated pipes or structures,

Use of mini enclosures,

Enclosure of asbestos materials,

Maintenance programs (refer to CHAPTER 4).

Handling ACM wet is one of the most reliable methods of ensuring that asbestos fibers do not become airborne. The wet method is the application of amended water by an airless sprayer. It should be used in combination with the other abatement methods. The ACM should be wetted prior to the start of maintenance operations and continuous application of wetting agents during the work. This is done to ensure that any dry ACM exposed during the work is wet and remains wet until final disposal.

Glove bags are approximately 40-inches wide by 64-inches long 6-mil thick plastic bags fitted with arms through which the work can be performed. They permit the worker to be completely isolated from the ACM removed. Glove bags provide a flexible, easily installed, and quickly dismantled temporary enclosure. They come pre-labeled with the asbestos warning label prescribed by OSHA and EPA for bags used to dispose of asbestos waste.

A mini enclosure may be optimum for the removal of asbestos from a small ventilation system or a medium length duct. such an enclosure should be constructed of 6-mil polyethylene plastic sheeting. It can be small enough to restrict entry to the work area to one worker. A schematic of a mini enclosure is shown in Figure 3. The enclosure is constructed by:

Affixing plastic sheeting to the walls with tape and spray adhesive;

Covering the floor with plastic and sealing the plastic covering the floor to the plastic on the wall;

Sealing any penetrations such as electrical conduits or pipes with tape; and

Constructing small change room, approximately three feet square, using 2 by 4 inch lumber, plastic sheeting, and staples or tape.

Removal of an entire pipe insulated with ACM may be more cost effective than stripping the insulation. Before cutting the pipe, the ACM must be wrapped with 6-mil plastic and securely sealed with tape. If the pipe is completely insulated, small sections should be stripped using the glove bag method. The pipe is then cut at the stripped sections and the entire pipe with ACM insulation is disposed.

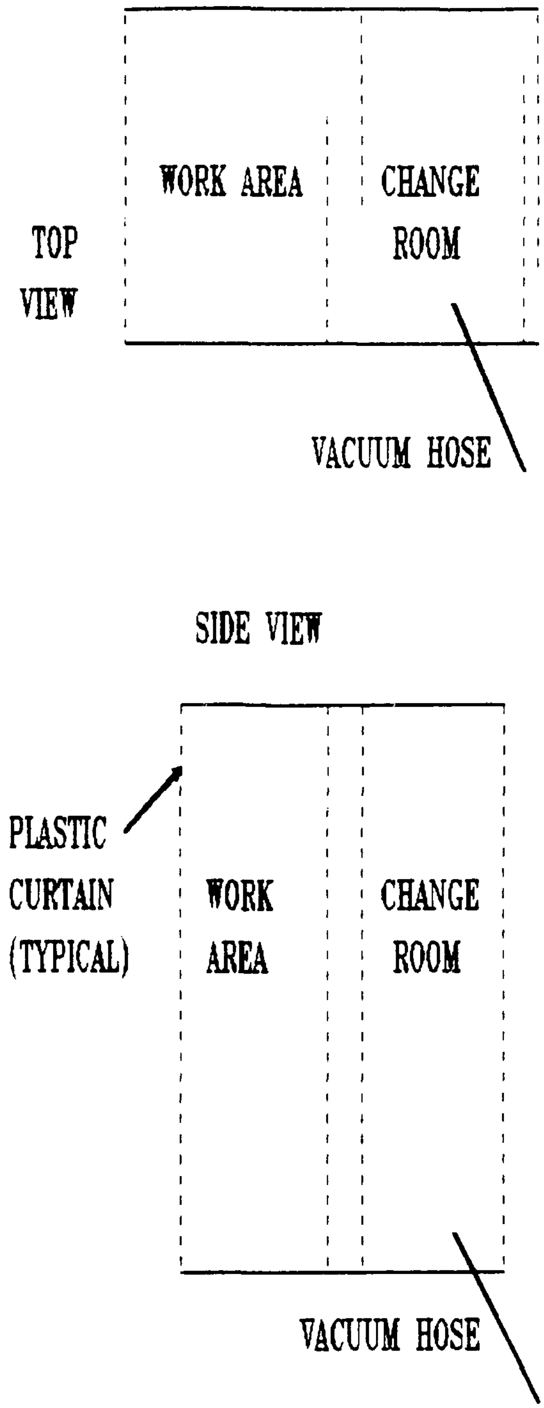

Figure 3. Mini Enclosure Schematic.

3.4 Disposal Procedures and Cleanup

Wastes that are generated by processes where ACM is present include: empty ACM shipping containers, process wastes such as cutting or rejected materials, housekeeping wastes for sweeping or vacuuming, ACM that is removed during renovation or demolition, and contaminated protective clothing. These wastes must be collected and disposed of in sealed, labeled, 6-mil thick plastic bags, plastic lined cardboard or metal containers. All asbestos waste materials must be consigned and should be disposed of at approved landfills. Contaminated equipment should be cleaned by HEPA vacuuming the surface and wet-wiped with amended water where feasible. Disposal procedures and cleanup are detailed in 29 CFR 1926.58, Appendix G.

The owner or operator of an active waste disposal site that receives ACM must comply with 40 CFR 61.154. The disposal site shall not discharge any visible emissions to the outside air during disposal. Rather than meet the no visible emission requirement, the following methods may be used: the ACM shall be covered with at least six inches of compacted non-asbestos material, or the ACM may be covered with a petroleum based dust suppression agent. The ACM that has been deposited at the site within the operating day or the previous 24 hour period must be covered at the end of the operating day or at least once every 24 hours. The suppression agent shall effectively bind the dust and control wind erosion.

The disposal site operators maintain waste shipment records for two years. Information included on the shipment documents include: name, address, and telephone number of waste generator and transporter, the quantity in cubic yards of ACM, and the date of receipt. The operators keep a map of the disposal area which shows the disposal location, depth and area, and quantity of ACM in cubic yards.

CHAPTER FOUR
OPERATIONS AND MAINTENANCE PROGRAM

4.1 Introduction

The EPA recommended to Congress in 1988 that the Agency work for the next three years to enhance the nation's technical capability in asbestos. This knowledge would help owners to better select and apply appropriate asbestos control and abatement actions to their buildings. The result of this work is the increased emphasis on in-place management of asbestos. The EPA has provided detailed and updated instructions on how to conduct a successful Operations and Maintenance (O&M) Program. This work informs owners, lenders, and insurers that a properly conducted O&M program can be as appropriate as asbestos removal.

To properly evaluate the potential hazard and risk of asbestos exposure, an owner must be aware that:

(1) The risk of asbestos related disease depends upon the exposure to airborne asbestos fibers;

(2) The average airborne asbestos levels in buildings seem to be very low (based on available data) thus, the health risk to most building occupants also appears to be very low;

(3) Removal of asbestos is often not an owner's optimum course of action and improper removal

can create a dangerous situation where none previously existed;

(4) Asbestos removal is required by EPA only to prevent significant public exposure to airborne asbestos fibers during building demolition or renovation; and

(5) EPA recommends a pro-active, in-place management program whenever ACM is discovered.

These facts should calm the fears that the public has about the mere presence of asbestos in their buildings. Owners should be discouraged from the spontaneous decision to remove all ACM regardless of its condition.

4.2 O&M Program

An operations and maintenance program are defined as a formulated plan of training, cleaning, work practices, and surveillance to maintain ACM in good condition. The principle objective of an O&M program is to minimize exposure of all building occupants to asbestos fibers. To accomplish this, the program includes work practices to: maintain ACM in good condition, ensure proper cleanup as asbestos fibers previously released, prevent further release of asbestos fibers, and monitor the condition of ACM.

An effective program will address all types of ACM present in a building. ACM can be classified in one of the following categories:

(1) Surfacing Material - ACM sprayed or trowel onto surfaces, such as decorative plaster of ceilings or acoustical ACM on the underside of concrete slabs or decking, fire-proofing materials on structural members;

(2) Thermal System Insulation (TSI) - Includes ACM applied to pipes, boilers, tanks, and ducts to prevent condensation or heat loss or gain; and

(3) Miscellaneous ACM - Includes asbestos containing ceiling or floor tiles, textiles, and other components such as asbestos cement panels, asbestos siding, and roofing materials.

The O&M program can be divided into three types of projects, those which: are unlikely to involve any direct contact with ACM, may cause accidental disturbance of ACM, and involve relatively small disturbances of ACM. An example of the first type is the routine cleaning of shelves and counter tops. Maintenance work above a suspended ceiling in an area that may have surfacing ACM overhead is a case of a type two project. The third type of project is the installation of new light fixtures in an ACM ceiling, which is a small-scale, short duration maintenance or repair activity. Asbestos removal for this type project is discussed in Chapter Three, Section 3.3.2.

A comprehensive asbestos control program for a facility should include these basic steps:

An Asbestos Program Manager should be appointed and an organization policy should be developed.

A visual and physical inspection of the facility should be conducted. Bulk samples of suspect materials should be taken to determine if they are ACM. An ACM inventory should be established. The condition and potential disturbance of the ACM should be assessed.

An O&M program should be developed based on the inspection and assessment data of the located ACM.

The O&M program should be implemented and activly managed. Abatement actions other than O&M should be selected and implemented when necessary (removal, enclosure, or encapsulation).

The asbestos program manager is key to a successful O&M program. The position is frequently held by the building engineer, superintendent, facility manager, or safety and health director. The person filling the position must be properly qualified, through training and experience. They must be actively involved in all asbestos control activities. Typical requisite training would be EPA accreditation under the Asbestos Hazard Emergency Response Act (AHERA) or state certification as a building inspector or management planner.

The commitment of the facility owner to a well developed O&M program will be evident by its effectiveness. The owner should incorporate the O&M program into the existing organization that manages the building's operations. Figure

4 shows an organization chart using in-house management staff. Figure 5 shows an organization chart where building services are contracted. Note that both require asbestos contractor services.

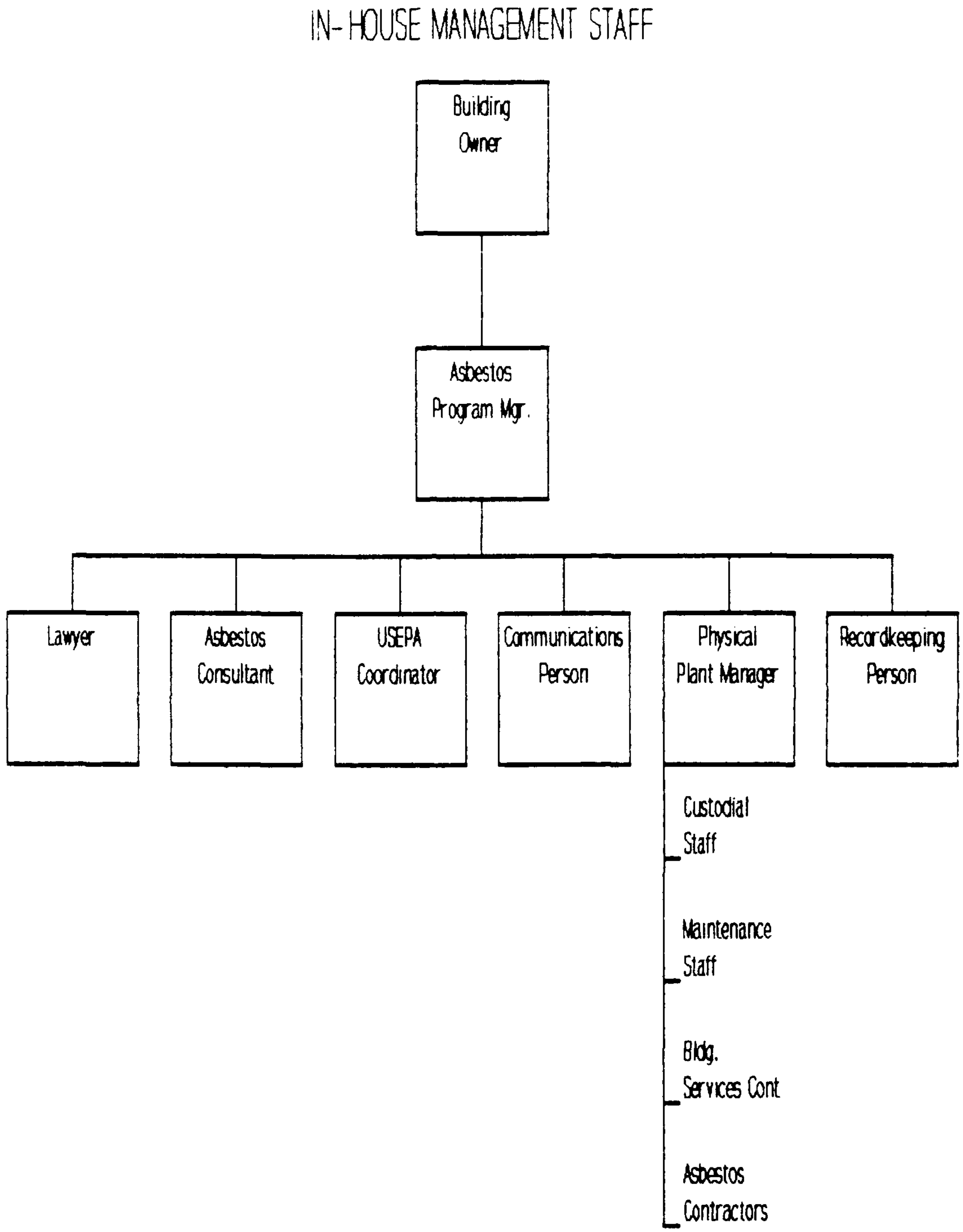

Figure 4: Organization for in-house management staff.

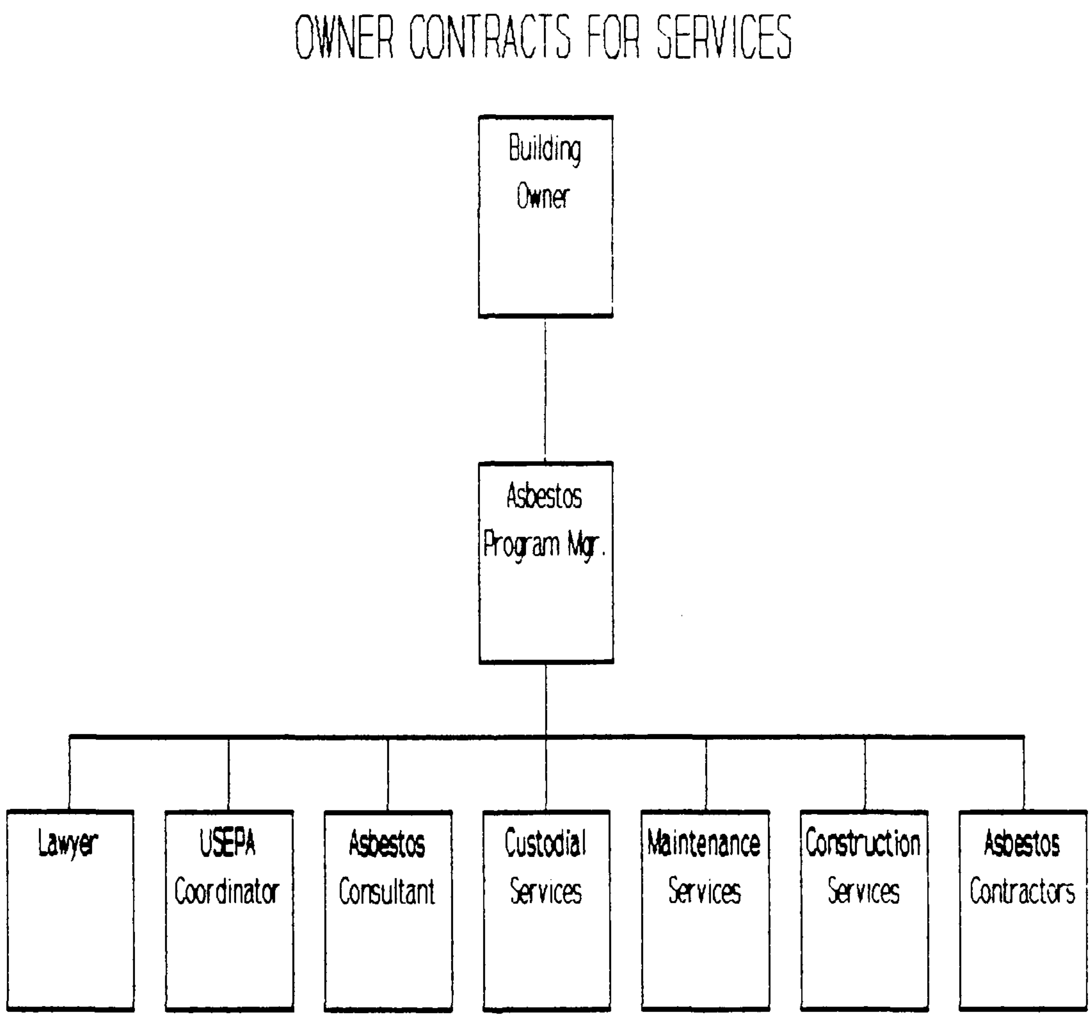

Figure 5: Organization for services contracted.

4.3 Cost Considerations

The costs associated with the implementation and management of an O&M program will vary depending on the following factors: types of ACM, building unique factors, O&M procedures adopted, types of equipment used, and the useful life of the building. The immediate large scale asbestos removal may be less cost effective than a well supervised and managed O&M program. In addition to the direct cost of removal, other related cost to ACM removal include relocating building occupants, providing alternative space for the occupants during removal, and restoring the building after the removal is completed. Owners must conduct a cost effectiveness analysis of the long term options to determine the most effective option for their building. Some long term options are: immediate removal, phased removal with O&M, removal at demolition with lifetime O&M.

General Services Administration (GSA) presented a paper comparing the asbestos-related O&M and abatement cost at the National Asbestos Conference on February 19, 1991. Based on the report using data for a typical government office building, the annual O&M costs for a building with asbestos-containing fireproofing and insulation are calculated to be 17.2 cents per square foot (sf) per year. This is economically equivalent to an abatement project cost of $3.03/sf. Removal costs for asbestos fireproofing is in the range of $15 to $25 per square foot. This is well above the

$3.03/sf equivalent cost of O&M with removal at time of demolition (14-1). Therefore, based on cost alone removal at present is not justified.

The economic evaluation of long term cycles of maintenance and remodeling shows when asbestos abatement can be appropriately considered. During the life of a building there are several times when asbestos abatement should be evaluated, during major repairs and alterations and the demolition of the building. The decision by the owner to remove all ACM may not be driven by economics. Other factors may determine the final decision on removal, such as inability to obtain insurance, or a requirement to obtain financing relative to a real estate transaction. An April 1989 EPA survey found that about 20 percent of all removal projects were conducted for reasons other than immediate health concerns. The report was based on interviews with abatement contractors and building owners. Current abatment activity takes place when buildings are renovated or sold. Lenders require the complete removal of asbestos or other abatement action as a condition to finace the purchase of the building (15-2).

In a 1988 EPA report to Congress on asbestos in buildings, the agency estimated that regulations requiring asbestos inspections and operations and maintenance programs for all public and commercical buildings would cost nearly $31 billion. Placing regulatory requirements similar to the AHERA law to all non-school public and commercial buildings would cost an estimated $51 billion (16-2). The current EPA recommendation is to consider in-place management as an ecomonic alternative to asbestos removal.

CHAPTER FIVE
ASBESTOS SUBSTITUTES

5.1 Introduction

Asbestos is a unique material which has many desirable characteristics as previously described. Alternative materials have recently become available that exhibit a variety of its physical properties: fiberglass, ceramic fibers, steel wool, rock wool, slag wool, cellulose, kaolin wool, exfoliated vermiculite, alumina, zirconia, aluminosilicates, graphite, aromatic polyamide, and polypropylene. There is no single substance that can replace asbestos in all applications that use asbestos.

Supply sources for asbestos exists in many places throughout the world. Prices of asbestos products are expected to rise, due partly to the stringent precautions imposed on product manufacture, and partly to the limited amount of asbestos as a natural resource. Ultimately, substitutes would have to be found on the grounds of availability and cost.

The United States has banned the use of asbestos under provisions of the Toxic Substances Control Act. The three stage process will be complete in 1997. A series of asbestos products exempt from the ban account for only 6 percent of total asbestos used in the United States. These exempted products include asbestos liners for missiles, asbestos thread, tape, and packing material, and several industrial products (17-7). Therefore, all construction materials must be replaced with suitable substitutes.

A realistic method of identifying substitute is to investigate each product group separately. Substitute products are divided into the following five groups:

(1) Products that have been available for many years as competitive and technically acceptable alternatives;

(2) Products that are developed to make asbestos-free materials, due to environmental pressures on asbestos;

(3) Replacement materials that take the place of certain asbestos products due to a shortage of specific grades or types of asbestos;

(4) Products that have been developed to higher specifica-tions which exceed those that asbestos can perform; and

(5) Redesigned products so the requirement for asbestos is removed.

A combination of these methods will be used in evaluating asbestos substitute materials for the construction industry. A discussion of the material substitutes will be followed by construction applications.

5.2 Materials

Fiberglass is the most common replacement material for asbestos and is relatively inexpensive. Available under various trade names, it is a generic name for glass fibers of a silica base. Fiberglass has a fairly high tensile strength and medium wear resistance. Some forms of fiberglass have high insulating properties and are very suitable for electrical work.

Alumina and Zirconia fibers are two distinct types of materials, but have similar mineral properties. Their exceptional temperature resistance make them suitable for use in hot, reducing atmospheres. They resist general chemical attack. Asbestos has a much higher tensile strength than alumina or ziconia. Both materials are very expensive.

Aluminosilicate fibers are a medium cost substitute available in a wide range of product forms. These fibers have a high temperature resistance and good strength characteristics. They are chemically affected by concentrated alkalis and hydrofluoric and phosphoric acids.

Graphite fibers are used for their high strength and are well known. They oxidize under ordinary conditions, but can withstand high temperatures. Protective coatings from oxidizing environments increase their high temperature applications. Graphite fibers apply only to very specific situations. Graphite is very expensive, a major disadvantage.

Du Pont Corporation produces synthetic fibers in a class of compounds known as aromatic polyamides or aramids. These fibers are marketed under the trade name of Kevlar and is relatively expensive. The fibers are relatively stiff and are unique in having extremely high strength and wear resistance characteristics. This material is nonabrasive with a low resistance to temperature, about 204 Celsius. Mixing Kevlar with other materials can cause problems as the fibers tend to bind together.

Polypropylene fibers are used as a substitute for asbestos in low temperature applications due to the low temperature resistance. These fibers have a good overall chemical resistance to acids and alkalis, and are easily handled. Its tensile strength is among the lowest of the substitute materials. An advantage of polypropylene is its low cost.

5.3 Applications

One or more of the substitute materials can be used to replace asbestos in building materials. It is critical to know where and who manufactured the building materials. Manufactures in Japan have the advantage that materials containing less than five percent asbestos are legally not considered to be asbestos products (18-82). World production and consumption of asbestos has dropped off in all industrialized countries except Japan and the Soviet Union.

The demand for asbestos has been increasing in Asia, South America, and the Middle East. Common building materials are listed below with a brief discussion of acceptable use of substitute materials. This listing is not all inclusive, covers the major building components.

5.3.1 Asbestos-cement Products

National and international standards govern the properties of asbestos-cement products. The following product groups are evaluated: corrugated sheets, flat sheet and building board, slates, and pressure (high and low) pipes. Fiber-reinforced cement is a process that bonds non-asbestos fibers with cement. Alternate fibers that may be used in fiber-reinforced cement (FRC) include: glass, cellulose, polyvinyl alcohol, and polypropylene. These fibers are used separately to produce corrugated and flat sheets, building boards, and slates. Polyvinyl alcohol and cellulose fibers are the main substitute fibers.

Sheet metals may be used for roof and wall cladding, sills, and skirting. Aluminum and stainless steel are a costly substitution for asbestos-cement products. Glass-reinforced plastic (GRP) may be used in flat or molded wall and roof cladding panels. GRP is combustible and produces large amounts of smoke and fumes when it burns.

Asbestos-cement pipe is a universal pipe material. Sheet and board products made of alternate fibers can be used as a substitute material. They do not work well for pipes because of the strength specifications required by national and international standards. Therefore, other material classes must be looked to for alternatives. In small bore pressure applications, unreinforced polyvinyl chloride (uPVC) and polyethylene are used. Ductile iron, glass reinforced plastic, and prestressed concrete are alternative materials for very large pipes. Glass reinforced plastic pipes (GRPP) are most suitable for transporting aggressive chemical solutions and use in desalination plants. Vitrified clay, PVC, concrete (both reinforced and unreinforced), and ductile iron are used in sewage and drainage applications.

5.3.2 Insulating Boards

Since the 1950's asbestos insulating boards and ceiling panels have been used to provide structural fibre protection, non-combustible surfaces, and humidity- and heat-resistant linings. They were designed to provide four hours fire resistance using standard tests. Asbestos was replaced by other heat-resistant materials, such as vermiculite, mica, and wollastonite, in the development of alternative products. Cellulose is combined with these materials in an autoclaved calcium silicate process. The new products are designed to meet the same fire-protection and general purpose applications as the asbestos product.

Glass-fiber-reinforced gypsum is another alternative material for use as a building board. Gypsum will dehydrate at or about 130 degrees Celsius and collapse. Using suitable reinforcement, gypsum board is incombustible and suitable for interior applications. Perlite may be incorporated for a lower strength lighter building panel.

5.3.3 Sprayed Coatings

Mineral wool fiber and vermiculite have replaced asbestos in sprayed coating applications. They are used for fire protection, anticondensation, and acoustical control. Vermiculite-Portland cement is sprayed on steel girder work to provide a four hour fire resistance, and is extensively used as fireproofing in mines.

5.3.4 Adhesives, Sealants, and Mastics

Pitch and asbestos are used in mastics and sealants in coating applications for roofing. Asbestos is used as a binding agent, and provides cohesion, viscosity, elasticity, plasticity, and durability. Bitumen based mastics and sealants may use glass fibers, aluminosilicate fibers, mica, wollastonite or talc as alternatives to asbestos. These materials do not have as good holding or bulking properties as asbestos. The mineral sepiolite, which has good holding, thixotropic, and binding properties, is becoming more commonly used in asphalt and bitumen-based compositions.

5.3.5 Roofing Felts

Asbestos felts impregnated with bitumen or asphalt have been used in roofing. The fire resistance, rot resistance, and dimensional stability of the asbestos are the important properties. Alternative roofing felts include those based on organic fibers and comprise impregnated cellulose, paper, and shoddy felts. Glass fiber in felt or mat form is an alternative reinforcement in roofing felts. Other roofing systems use combinations of components: a mineral filled pitch is sandwiched between glass fabric outer layers bonded with acrylic resin; asphalt or bitumen combined with polystyrene or polyurethane foam with glass fiber fabric as reinforcement; an organic system in which polyolefin fibers are combined into asphalt.

5.3.6 Flooring and Floor Tiles

Asbestos fibers provide wearing resistance and non-slip properties in floor tiles. Glass or mineral wool fibers may be used as alternative fibers, but make for a brittle product. Combinations of glass fibers with cellulose or synthetic fibers do not provide the same non-slip properties as asbestos. Expensive vinyl polymers, which do not require fiber reinforcement for dimensional stability, have replaced vinyl asbestos floor tiles. Glass or mineral fibers have replaced asbestos in the backing felt for continuous vinyl floor coverings.

5.3.7 Thermal Insulation

Applications of asbestos and its substitutes in thermal insulation encompasses three main areas: insulation board (Section 5.3.2), sprayed coatings (Section 5.3.3), and lagging. Many heat-resistant fibers can be made into textiles, which will be discussed in this section.

Heat-resistant textiles must withstand extreme conditions, service temperatures in the range of 200 to above 1200 degrees Celsius. Applications of heat-resistant textiles are: personal protective garments; safety curtains in theaters; welding screens; fire blankets; flange seals on oven and boiler doors; thermal insulation on pipes and boilers; conveyor belting; flue curtains; hot gas filtration; fire barriers in electrical switchgear and for wrapping field and armature coils in large power generators; and packing and jointing. Inorganic refractory fibers have better temperature performance than asbestos, while synthetic organic fibers and glass fibers perform poorer. Glass and the cheapest of the aluminosilicate ceramic fibers are the only materials close to being competitive with asbestos for this application.

The following fibers may be used as a substitute for asbestos fibers: organic, aramid, carbon, polytetrafluoroethylene (PTFE), glass, and refractory ceramic. Aramid fibers are the most expensive of the synthetic fibers. Kevlar is the most widely known aramid fiber. Kevlar fabric is used in high-performance and high-technology area. Applications for

Kevlar fabric include: industrial gloves, protective armlets and leggings, bullet-resistant vests, and hard armor. Carbon textiles have limited use in protective clothing, but is used for military personnel clothing. Using activated carbon fibers to absorb bacteria, carbon textiles are used as curtains and shields in mobile operating room and clinics. A specific application for fabrics based on activated carbon is in protective clothing, where there are gaseous and liquid hazards. PTFE fibers are used in coverall garment for astronauts because it is the most fire-resistant organic fiber in oxygen rich and pressurized atmospheres. Glass textiles are used for safety curtains, aprons, blankets, and insulation covers. Refractory textiles are used in high-temperature insulation above the limits of asbestos.

Wool and leather are materials that are an alternative to asbestos. Wool is a traditional material used by metal foundry workers against heat and molten metal splash. Leather gloves and pads provide short term protection against heat-- resist sparks, chips, and rough objects-- and provides some cushion against blows.

Man-made mineral fibers (MMMF) include glass wools, rock wools, and slag wools. MMMF insulation products have a lower density and lower thermal conductivity than their asbestos counterparts. Their uses vary from insulating roofs and walls to high temperature applications for ovens, furnaces, and pipework in power plants. Other excellent thermal insulating minerals are perlite and vermiculite. Expanded vermiculites and perlites make loose fill insulation. They may be bonded to form rigid insulation. Bonded perlite is used to insulation slabs and pipework. Expanded perlite can be used to make refractory bricks, for use up to 925 degrees Celsius.

5.3.8 Millboard

Millboard is a very versatile asbestos material due to: ease of cutting or punching to size or shape, thermal insulation properties, compressibility, ability to be wet-molded, and ability to be impregnated with bonding agents and cements. Millboard is used for fabrication of rollers for the transportation of hot materials in the steel and glass industries, flange gaskets, cylinder head gaskets, insulating linings in ovens and molds, and for low voltage electrical insulation at temperatures up to 180 degrees Celsius. A direct replacement for asbestos, for many applications, is millboard made from aluminosilicate fibers or mineral wool fibers. These fibers are bonded with a high temperature silica binder. Cellulose fibers may be used for less stringent millboard applications.

CHAPTER SIX
CONTRACTOR SELECTION

6.1 Introduction

A contractor is usually hired to conduct abatement work that is beyond O&M scope. Asbestos abatement projects require a high level of experience and expertise from all members of the abatement team. The abatement contractor carries a large burden as the "hands-on" member. They are required to complete difficult tasks, under difficult conditions, while meeting stringent requirements imposed by regulations and detailed contract specifications. The first step toward a successful abatement project is to select the best contractor. This will enhance the success of the overall asbestos control and management effort (19-136).

6.2 Qualifications

Qualification, either before or during bidding, of contractors is not foolproof, but often helps avoid misunderstandings. Steps in selecting a contractor include checking references, conducting interviews, reviewing insurance coverage, and writing precise contract specifications. It must be noted that the most cost-effective contractor is not necessarily the lowest bidder.

Writing a precise contract specification may require the hiring of consultants and the use of model contract specifications. The following organizations have developed model guide specifications for asbestos abatement: National Institute of Building Sciences, Federal Construction Guide Specifications, and Association of the Wall/Ceiling Industries. These models may serve as the basis for writing specifications tailored to the individual project.

Some contractors cannot properly conduct abatement projects based on EPA's experience with asbestos abatement and comments from technical advisors. Contractors, awarded jobs based on responsive and reasonable cost bids, may be unable or unwilling to follow contract specifications. The following suggestions may help owners to avoid these situations:

Assign the technical advisor, who will monitor the abatement work, to assist in writing the job specifications and selecting the contractor.

Require evidence of prospective contractor's experience and training in asbestos abatement.

Check references to include other building owners which the contractor has completed similar type work.

Ask for detailed written description of how bidders will satisfy the project specifications.

Interview bidders regarding their work, worker protection, and site containment plans. Ask for copies of their standard operating procedures and employee protection plans.

Be sure that the contractor selected has adequate liability insurance. The building owner's attorney and insurance advisor should determine if coverage is adequate.

Be specific about what constitutes job completion. A thorough visual inspection to insure adequate cleaning should be a requirement. Air monitoring is highly recommended. An independent firm should be responsible for air monitoring.

Have the contractor conduct an on-site training program for workers or preferable provide evidence of worker certification.

Avoid contracting for abatement work during the summer. Many school projects are conducted during that season, taxing the limited number on competent contractors.

Encourage competitive bidding as prices can very significantly. Multiple bids may be desired, but too many can confuse the selection process. Successful abatement is the primary goal, cost minimization is secondary (20-6-2).

Other areas of qualifications should not be ignored. Credit status, frequent corporate name changes, bonding limits, and any regulatory citations under present or former corporate names can shed significate light on a company. A company may be new, but its principles and key supervisory personnel may have extensive experience. Three years of abatement experience is considered a minimum requirement (21-136).

6.3 Liabilities

Asbestos is regulated by the federal government under a number of laws. The regulations of primary importance to the owners and contractors are the asbestos standards established under the National Emission Standards for Hazardous Air Pollutants (NESHAP) of the federal Clean Air Act. Environmental laws are not specific as to who may be held liable. Asbestos or other hazardous materials are no different than other risks. All business transactions have risks; the question is how these risks are allocated. Knowledge of what the risk consists of is the first step in determining how the owner may allocate the risks. This can be best determined by a detailed environmental audit. Lenders are now requiring audits before approving financing.

6.3.1 Contractors

The EPA has estimated that there are over 100,000 renovations and demolition jobs involving ACM each year. The agency has been aggressively enforcing asbestos regulations against contractors and owners due to the perception that there is only a 50 percent compliance rate with the work practice rules at construction sites. A site operator was recently indicted for knowingly filing a false notification of renovation work. In the case, the principal owner of a demolition firm was charged with a felony because the contractor initially failed to provide the notice required by the NESHAP regulations. When the notice was submitted, an EPA site inspection revealed that the work had already begun prior to the stated date submitted. The minimum penalty for NESHAP violators is now based on the costs avoided by noncompliance. EPA has determined this is $20 per linear foot for each improperly performed job site (22-76). Violations of New York City's ACM removal provisions may be subject the offender to fines of up to $25,000 per day and/or imprisonment of not more than one year.

In addition to penalties for failure to comply with applicable regulations, the contractors may lose their bonding and liability insurance. Contractor costs for liability insurance are 10 to 15 percent of project revenues based on a 1990 EPA report. The high cost is due to the fear of insures about liberal legal standards that might be applied to asbestos claims. "Insurers, to date, have been unable to provide any case law that supports these contentions with regard to asbestos abatement contractors or consultants," EPA said (23-8). Bonding for asbestos abatement contractors has been reduced for fear of having to fund damage payments for asbestos injuries. There is no specific court ruling that bonds could be used to settle liability claims. The availability of bonding and liability insurance is improving as the asbestos abatement industry matures and courts settle the issues of liability.

6.3.2 Owners

The owner of a building that has asbestos owns the asbestos for life. The owner organization, under regulations at multi-jurisdictional levels (federal and state statues and regulations, and local ordinances), will be held liable if it knows, or should know, of the likelihood of any asbestos, and there is a resulting injury to a party. They may be liable even for the clean up in some cases.

If there is a default, the lender becomes the possessor of a property having hazardous waste problems. Therefore, lenders now require an environmental audit or similar evaluation of a property prior to approving financing for construction, purchase or remodeling. The Federal National Mortgage Association (Fannie Mae) has instituted an environmental hazards management program which contains comprehensive asbestos inspection requirements. The Fannie Mae asbestos requirements only apply to the secondary market, but have an impact on developers and building management seeking for finance construction or rehabilitation projects (24-75).

The owner is required to notify tenants and anyone working in the building, including contractors, janitors, and security guards, about the presence of asbestos. An owner can be held liable if occupants or visitors are injured by exposure to asbestos. Even if the owner suspects that ACM is in the building but delays instituting abatement procedures, they may be found negligent for exposing plaintiffs to the asbestos. The owner may also be liable if a contractor negligently performs renovation work that exposes occupants to asbestos (25-77).

The critical step in asbestos abatement is to establish a baseline of the current asbestos conditions for a property. The owner should develop an effective management plan that covers the rights and obligations of both owners and tenants. Asbestos can be monitored and controlled safely and cost effectively. It is a matter of knowing what the risks are and allocating the cost accordingly (26-15).

6.3.3 Government

Federal and state governments are responsible for the management and abatement of asbestos on their respective properties. The regulations that apply to public work are the same as those for private work. Abatement funds have be provide at all levels of government for asbestos abatement. The regulatory agencies should actively enforce the asbestos regulations to ensure public health is protected. Agencies should stay abreast of changing technology and encourage effective management of all hazardous waste.

CHAPTER SEVEN
CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

Asbestos abatement will continue well into the twenty-first century. The United States has taken the lead with an asbestos ban and the phasing out of new products by 1997. Other nations are being encourage to follow this example, but Japan and other Asian nations still import large quantities of asbestos products. Asbestos standards vary around the world. International standardization of asbestos products, removal and disposal methods will be needed in a global economy.

The asbestos abatement sector of the construction industry will continue to grow slowly, but steadily. Their services will continue to be highly regulated, but procedures have been developed which minimize the risks. The application of robotics may reduce costs and minimize exposure to humans. There is a global market which will not be fully developed for years. The combination of O&M services with asbestos abatement capabilities provide unlimited potential for contractors in the future.

7.2 Recommendations for Future Research

Alternative methods for disposal of asbestos waste should be investigated. The land available for landfill disposal is limited. In the future, asbestos waste disposed in covered landfills may pose an even greater hazard. The conversion of the largest asbestos mine in California to a disposal facility is an excellent idea. The site has a 1,000 feet deep pit which has the capacity to hold more than 16 million cubic yards of asbestos waste (27-1). This waste should not be disturbed. The manufacture of glass and metal products from asbestos waste is another innovative idea. Omega Phase Transformation Incorporated has petitioned the EPA for a wavier of the asbestos ban and phase out rule to manufacture such a product (28-6).

Further study on the health risks of substitute materials use to replace asbestos is needed. The University of Minnesota School of Public Health is performing a three year study which will complete in mid-1991. The study is evaluating man-made fibers and the possible link to asbestos related diseases (29-5).

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APPENDIX A
ASBESTOS CONTAINING MATERIALS FOUND IN BUILDINGS

Subdivision	Generic name	Dates of use
Surfacing material	sprayed or troweled-on	1935-1970
Preformed thermal insulating products	batts, blocks, and pipe covering	
	85% magnesia	1926-1949
	calcium silicate	1949-1971
Textiles	cloth fire blankets	1910-present
	felts: blue, green, red stripe	1920-present
	sheets	1920-present
	cord/rope/yarn	1920-present
	tubing	1920-present
	tape/strip	1920-present
	curtains:	
	theater, welding	1945-present
Cementitious concrete-like products	extrusion panels:	1965-1977
	corrugated	1930-present
	flat	1930-present
	flexible	1930-present
	flexible perforated	1930-present
	laminated (outer surface)	1930-present
	roof tiles	1930-present
	clapboard and shingles:	
	clapboard	1944-1945
	siding shingles	unkn-present
	roofing shingles	unkn-present
	pipe	1935-present
Paper products	corrugated:	
	high temperature	1935-present
	moderate temperature	1910-present
	indented	1935-present
	millboard	1925-present

Note: present equates to 1981, the date this data was first published. See footnote. unkn= unknown

APPENDIX A (continued)

Subdivision	Generic name	Dates of use
Roofing felts	smooth surface	1910-present
	mineral surface	1910-present
	singles	1971-1974
	pipeline	1920-present
Asbestos containing compounds	caulking putties	1930-present
	adhesive (cold applied)	1945-present
	joint compound	1945-1975
	roofing asphalt	unkn-present
	mastic	1920-present
	asphalt tile cement	1959-present
	roof putty	unkn-present
	plaster/stucco	unkn-present
	spacklers	1930-1975
	sealants fire/water	1935-present
	cement, insulation	1900-1973
	cement, finishing	1926-1950
	cement, magnesia	1930-present
Asbestos ebony products		
Flooring tile and Sheet goods	vinyl/asbestos tile	1950-present
	asphalt/asbestos tile	1920-present
	sheet goods/resilient	1950-present
Wall covering	vinyl wallpaper	unkn-present
Paints and coatings	roof coating	1900-present
	air tight	1940-present

* The information in this Appendix is taken, with modification, from: Lory E. E., Coin D.C., February 1981, Management Procedure for Assessment of Friable Asbestos Insulating Material, Port Hueneme, CA: Civil Engineering Laboratory Naval Construction Battalion Center. The U.S. Navy prohibits the use of asbestos-containing materials when acceptable non-asbestos substitutes have been identified (30-A1-A2).

30. EPA 560/5-85-024, op. cit., pp. A1-A2.

APPENDIX B
GLOSSARY OF TERMS

Abatement- Procedures to control fiber release for asbestos containing materials. Includes removal, encapsulation, repair, and renovation activities.

ACM- Asbestos Containing Material. Any material containing more than one percent asbestos.

Air Monitoring- The process of measuring the fiber content of a known volume of air collected during a specific period of time.

Amended Water- Water to which a surfactant has been added.

Asbestos- A group of naturally occurring minerals that separate into fibers. There are six asbestos minerals used commercially: Chrysotile, Amosite, Crocidolite, Anthophyllite, Tremolite, and Actinolite.

Asbestos Program Manager- A building owner or designated representative who supervises all aspects of the facility asbestos management and control program.

Cementitious- Friable materials that are densely packed and non-fibrous.

Clean Room- An uncontaminated area or room which is a part of the worker decontamination enclosure system with provisions for storage of worker's street clothes and clean protective equipment.

Containment- Isolation of the work area from the rest of the building to prevent escape of asbestos fibers.

Decontamination Chamber- A series of connected rooms, separated from the work area and from each other by air locks. Used for the decontamination of workers and equipment.

Delamination- Separation of one layer from another.

Encapsulation- The application of an encapsulating material to asbestos containing material to control the release of asbestos fibers into the air.

EPA- U.S. Environmental Protection Agency.

Equipment Room- A contaminated area or room which is part of the worker decontamination enclosure system with provisions for storage of contaminated clothing and equipment.

Exposure (Human)- The total amount of airborne contaminant inhaled by a person, typically approximated by the product of concentration and duration.

Fibrous- Spongy, fluffy, composed of long strands of fibers.

Friable Asbestos- Any material that contains greater than one percent asbestos, and which can be crumbled, pulverized, or reduced to powder by hand pressure. This may also include previously non-friable material which becomes broken or damaged by mechanical force.

Glovebag- A polyethylene or polyvinyl chloride bag-like enclosure affixed around an asbestos-containing source so that the material may be removed while minimizing the release of airborne fibers to the surrounding atmosphere.

HEPA Filter- High- Efficiency Particulate Air Filter. Such filters are rated to trap at least 99.97% of all particles 0.3 microns in diameter or larger.

HEPA Vacuum- A vacuum system equipped with HEPA filtration.

Miscellaneous ACM- Interior asbestos containing building material on structural components, structural members or fixtures, such as floor and ceiling tiles.

Negative Pressure Ventilation System- A portable exhaust system equipped with HEPA filtration and capable of maintaining a constant low velocity air flow into contaminated areas from adjacent uncontaminated areas.

NESHAPS- National Emission Standard for Hazardous Air Pollutants, the EPA Rules under the Clean Air Act.

NIOSH- National Institute for Occupational Safety and Health, established by the Occupational Safety and Health Act of 1970. Primary functions are to conduct research, issue technical information, and test and certify respirators.

OSHA- Occupation Safety and Health Administration.

Reintrainment- The disturbance of fibers already separated from the main body so that they re-suspend into the atmosphere after having initially settled.

Removal- Specified procedures necessary to strip all asbestos-containing material s form the designated areas and to dispose of these materials at an acceptable site.

Risk- The likelihood of developing a disease as a result of exposure to a contaminant.

Shower Room- A room between the clean room and the equipment room in the worker decontamination enclosure with hot and cold running water, suitably arranged for complete showering during decontamination.

Surfacing ACM- Asbestos-containing material that is sprayed-on, troweled-on or otherwise applied to surfaces or other materials on surfaces for acoustical, fireproofing, or other purposes.

Surfactant- A chemical wetting agent added to water to improve penetration.

TSI- Thermal System Insulation, asbestos-containing material applied to pipes, fittings, boilers, breeching, tanks, ducts, or other interior structural components to prevent heat loss or gain or water condensation.

TWA- Time-weighted Average. In air sampling, this refers to the average concentration of contaminants during a particular sampling period.

Wet Cleaning- The process of eliminating asbestos contamination from building surfaces and objects by using cloths, mops, or other cleaning utensils which have been dampened with water. Afterwards, they are thoroughly decontaminated or disposed of as asbestos contaminated waste.