Asbestos Abatement Worker Refresher

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Section

PREFACE

ASBESTOS ABATEMENT WORKER REFRESHER

Title

HOW TO USE THIS MANUAL

MANUAL OBJECTIVE

The *Asbestos Abatement Worker Refresher* manual presents training information and other important aspects of what you, as a Construction Craft Laborer, must know to work safely, effectively, and efficiently on an asbestos abatement job site. It will instruct you in the correct asbestos abatement techniques as well as provide safety and health information regarding this hazardous substance.

HOW TO USE THIS MANUAL

Each **Section** in the manual covers a major component of the job. Concepts you will learn in each section are listed at the beginning as **Trainee Objectives**. At the end of each section, you will be expected to complete an **Assignment Sheet**. In addition, Section 5 contains **Standard Operating Procedures**, which are hands-on exercises to help you become familiar with wearing and caring for a respirator. Together, the parts of this manual will prepare you to work on an asbestos abatement job site.

In the **Regulations** section, you will find a copy of the Asbestos Standard, 29 CFR 1926.1101. The **Appendix** section contains information on contacting OSHA. Words that may be new to you are *italicized* in the text, and those words and their definitions are found in the **Glossary**.

THANK YOU

Thank you for placing your trust in Laborers-AGC training manuals. We believe this manual will instruct you in the most significant, useful, and up-to-date technical information and safety aspects of your job.

ASBESTOS ABATEMENT WORKER REFRESHER

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Section
1

ASBESTOS ABATEMENT WORKER REFRESHER

Title

INTRODUCTION TO ASBESTOS

TRAINEE OBJECTIVES

After completing Section 1, you will be able to:

1. Define the following terms and acronyms:

   ACM
   EPA
   Asbestos fiber
   Friable asbestos-containing material
   Micron
   Nonfriable asbestos-containing material
   OSHA
   PACM
   PEL
   SM
   TSI

2. List the six types of asbestos as defined by OSHA.
3. List the two most common types of asbestos used in construction.
4. Explain the difference between friable and nonfriable asbestos-containing materials.
5. Give the OSHA permissible exposure limit for asbestos.
6. Describe a Class I asbestos work activity.
7. Describe a Class II asbestos work activity.
8. Describe a Class III asbestos work activity.
9. Describe a Class IV asbestos work activity.

WHAT IS ASBESTOS?

Asbestos is a mineral that is found throughout the world. When asbestos is mined and processed it easily separates into long flexible fibers. These fibers are suitable for use as a noncombustible, nonconducting, or chemically-resistant material. In other words, asbestos fibers do not burn, breakdown, conduct electricity, or decompose.

There are two main forms of asbestos:

1. The *serpentine* form of asbestos is characterized by long, flexible, finely polished strands that can be woven into cloth.

2. The *amphibole* form of asbestos is characterized by its straight, needle-like fibers.

Asbestos products are manufactured by combining milled asbestos fibers with binders, fillers, and other materials. The product mixture, which may be either dry or wet, is molded, formed, sprayed, and then cured or dried. Some products require further machining or coating operations before sale.

ASBESTOS-CONTAINING MATERIALS

The Occupational Safety and Health Administration (*OSHA*) defines *asbestos-containing materials* (*ACM*) as "any material containing more than 1 percent asbestos." The following are three classifications of ACM:

- Nonfriable ACM
- Friable ACM
- Presumed ACM

Nonfriable ACM

The Environmental Protection Agency (*EPA*) defines *nonfriable asbestos-containing materials* as "any material containing more than 1 percent asbestos that, when dry, can not be crumbled, pulverized, or reduced to powder by hand pressure."

Friable ACM

The EPA defines *friable asbestos-containing materials* as "any material containing more than 1 percent asbestos, which has been applied on ceilings, walls, structural members, piping, duct work, or any other part of a building, which, when dry, may be crumbled, pulverized, or reduced to powder by hand pressure. The term includes nonfriable ACM after such previously nonfriable material becomes damaged to the extent that when dry it may be crumbled, pulverized, or reduced to powder by hand pressure." Most of the blown-on type fireproofing insulation, pipe coverings, and magnesium blocks are friable.

Presumed ACM

OSHA defines *presumed asbestos-containing material* (*PACM*) as "thermal system insulation and surfacing material found in buildings constructed no later than 1980." OSHA presumes that a material contains asbestos because workers cannot tell if a material contains asbestos simply by looking at it. Because laboratory analysis is not always possible or practical, workers should presume that all materials fitting the description of PACMs contain asbestos.

HISTORY OF ASBESTOS BAN AND PHASEOUT

By 1978, the manufacturing of new asbestos products was banned in the U.S. The only time an asbestos product could continue to be manufactured was when an adequate non-asbestos replacement product could not be found.

In 1999, the EPA released a clarification with regard to the status of asbestos products that are banned by the EPA as well as categories of ACMs that are not subject to a ban, which are shown in Table 1-1.

Table 1-2 is a summary of asbestos-containing products, which shows the average percentage of asbestos contained in a product, the binder used, and the approximate dates the asbestos-containing product was used. In many cases, products still employ the use of asbestos.

Table 1-1. Status of asbestos-containing product categories.

Product categories still banned:

- Corrugated paper
- Rollboard
- Commercial paper
- Speciality paper
- Flooring felt
- New uses of asbestos

Products NOT banned:

- Asbestos-cement corrugated sheet
- Asbestos-cement flat sheet
- Asbestos clothing
- Pipeline wrap
- Roofing felt
- Vinyl-asbestos floor tile
- Asbestos-cement shingle
- Millboard
- Asbestos-cement pipe
- Automatic transmission components
- Clutch facings
- Friction materials
- Disc brake pads, drum brake linings, and brake blocks
- Gaskets
- Nonroofing coatings
- Roof coatings

Table 1-2. Summary of asbestos-containing products.

Product	Average Percent Asbestos	Binder	Dates Used
Friction products	50	Various polymers	1910–present
Plastic floor tile/sheeting	20	PVC and asphalt	1950–present
Coatings/sealants	10	Asphalt	1900–present
Ridged plastic	>50	Phenolic resin	Unknown–present
Cement pipe/sheets	20	Portland cement	1930–present
Roofing felt	15	Asphalt	1910–present
Gaskets	80	Various polymers	Unknown–present
Corrugated paper pipe wrap	80	Starch and sodium silicates	1910–present
Other types of paper	80	Polymer starches, silicates	1910–present
Textile products	90	Cotton, wool	1910–present
Insulating/decorative sprays	50	Portland cement, silicates, organic binders	1935–1978
Troweled coating	70	Portland cement, silicates	1935–1978
Pre-formed pipe wrap	50	Magnesium, carbonate, calcium silicate	1926 –1975
Insulation board	30	Silicates	Unknown
Boiler insulation	10	Magnesium, carbonate, calcium silicate	1890–1978

USES OF ASBESTOS

At one time, asbestos was one of the most widely used minerals in many industries due to its unique properties, which include:

- Easily accessible and available
- Resistant to corrosion and flames
- Durable
- *Tensile* strength (Tensile means having the ability to be stretched or extended.)
- Flexible

Since then, consumption and use of asbestos nationally has dropped more than 70 percent because of the health risks to workers and the public. Even though the use of asbestos has dropped, asbestos still exists today in many of the buildings where it was originally installed.

ACMs are commonly found in commodities used in:

- Construction
- Thermal insulation
- Household products
- Fire protection
- Brake linings/clutch linings

Construction

Asbestos has been used in construction in exterior siding shingles, asphalt paving mix, spackle, and joint compounds.

Other uses of asbestos in construction include:

- Asbestos-cement (*AC*) or transite pipe is widely used for water and sewer mains. Occasionally, the AC pipe has been used for electrical conduits, drainage pipes, and vent pipes.

- AC sheets, manufactured in flat or corrugated panels and shingles, have been used primarily for roofing and siding. However, they are also used for cooling tower fill sheets, canal bulkheads, laboratory tables, and electrical switching gear panels.

The following are two types of asbestos applications used in construction:

1. Surfacing materials
2. Thermal system insulation materials

Surfacing Materials

Asbestos-containing *surfacing materials* (*SM*s) were often sprayed on ceiling surfaces to alter sound acoustics or troweled on structures for fireproofing purposes.

TSI Materials

Thermal system insulation (*TSI*) materials were often used for insulation purposes. This material was applied to pipes, fittings, boilers, breeching, tanks, ducts, and other structural components to prevent heat loss or gain.

In addition, TSI materials were used as a lagging material for wrapping boilers, hot water pipes, and steam pipes.

Asbestos-containing TSI materials generally refer to sprayed and troweled asbestos coatings and molded or wet applied pipe coverings. These materials usually have an asbestos content of 50 to 80 percent. The coatings were commonly applied to steel I-beams and decks, concrete ceilings and walls, and hot water tanks and boilers. The coatings were applied primarily for thermal insulation, although in many cases the coated material also provided acoustical insulation and a decorative finish. Typically, sprayed coatings have a rough, fluffy appearance. Troweled coatings have a smooth finish that can be covered with a layer of plaster or other non-asbestos material. Both sprayed and troweled asbestos coatings are considered friable in most applications. Most spray-applied asbestos coatings for fireproofing and insulating were banned in 1971. In 1978, decorative asbestos coatings were banned.

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TYPES OF ASBESTOS

According to OSHA, there are six types of asbestos fibers:

1. Chrysotile
2. Amosite
3. Crocidolite
4. Anthophyllite
5. Actinolite
6. Tremolite

Chrysotile

Chrysotile, which is also known as white asbestos, is a serpentine form of asbestos.

Chrysotile has long, white silky fibers that can be woven into cloth. The body of the fiber has a herringbone effect, and the ends of the fibers are similar to frayed rope.

Chrysotile asbestos is especially resistant to heat and can withstand a temperature of 932°F (Fahrenheit) or 500°C (Centigrade).

Amosite

Amosite has coarse, brownish fibers that are highly acid resistant. The body of the fiber has a smooth, spear-like appearance, and the ends look broken and jagged. Amosite is difficult to keep wet during abatement projects because it tends to shed water. It can also become airborne easily with very little air movement.

Crocidolite

Other than being bluish, *crocidolite* fibers appear almost identical to amosite. They are also difficult to keep wet. Amosite and crocidolite fibers are commonly found together in their natural form. The needle-like structure of crocidolite enables it to penetrate deeper into body tissues than other types of asbestos.

Crocidolite is highly resistant to acid, but it is less resistant to heat than other asbestos and can only withstand a temperature of 200°C or 392°F.

Anthophyllite

Anthophyllite is the coarsest asbestos mineral mined. This type of asbestos is inflexible and less heat resistant than most asbestos. It can only withstand a temperature of 200°C or 392°F.

Actinolite and Tremolite

Actinolite and *tremolite* asbestos made up less than 1 percent of the world's production of asbestos. Even though actinolite is resistant to acid and heat, it was rarely used. Tremolite is a brittle asbestos but with good heat resistance. It is found to occur more often as a natural contaminant of chrysotile deposits and talc. Tremolite is usually found as a contaminant in talc, sand, or vermiculite (a light water-absorbing mineral) deposits.

MEASURING ASBESTOS FIBERS

Most asbestos fibers cannot be seen without a microscope. Asbestos fibers are capable of remaining airborne for many hours because of their size, weight, and aerodynamic qualities. The concentration of airborne asbestos fibers plays a major role in determining the risk of respiratory diseases to exposed workers and the necessary level of respiratory protection required.

Because of the extremely small size of asbestos particles, they must be viewed with a microscope. When viewed under a microscope the asbestos particles are classified as fibers when they meet the criteria for fiber limits and lengths.

Fiber Limits

OSHA defines an asbestos fiber as a "particulate form of asbestos, 5 micrometers or longer, with a length-to-diameter ratio of at least 3:1." The levels of asbestos fibers or fiber concentration in air is measured by counting the fibers present in a certain volume of air. The current OSHA asbestos standard, 29 *CFR* 1926.1101, sets the *permissible exposure limit* (*PEL*) for asbestos as 0.1 fibers per cubic centimeter (*f/cc*) of air as an 8-hour time weighted average (*TWA*). PELs are set by OSHA and are legally enforceable.

A cubic centimeter is a volume of air about the size of a sugar cube. The OSHA Standard 29 CFR 1926.1101 states that one-tenth of a fiber or less is permitted in every cubic centimeter of air in a work area, averaged over an 8-hour period. (Workers still breathe in some asbestos fibers even if the work area meets OSHA regulations.) OSHA has also issued an excursion limit for asbestos of 1.0 f/cc averaged over a sampling period of 30 minutes. Additional information on the sampling of asbestos will be covered later in this manual.

Fiber Lengths

Fiber lengths are measured in micrometers (µm). The term *micron* or *micrometer* is used to describe the dimensions of an asbestos fiber. There are 1,000 µm in 1 millimeter (*mm*). Asbestos fibers have a length range of .1 µm to tens of micrometers. The size of an asbestos fiber as compared to a human hair is shown in Figure 1-1. The comparison of asbestos to other substances and measurement techniques is shown in Figure 1-2.

CLASSIFICATION OF ASBESTOS WORK

Due to the dangers associated with occupational asbestos exposure, OSHA created laws and regulations to protect workers. 29 CFR 1926.1101 specifically applies to construction workers who are exposed to asbestos on the job. The standard has changed over the past ten years to incorporate new information on occupational exposure to asbestos.

One of the newest changes issued by OSHA is the classification of work in construction that involves potential worker exposure to asbestos. This classification system takes into account that some worker activities involve potential exposures that are very high while others are very low. By tying potential exposures to work activities on specific types of ACMs, OSHA has developed specific regulations for each of the classes of work.

The new system classifies asbestos work as:

- Class I
- Class II
- Class III
- Class IV

The possibility of exposure to asbestos varies depending on the nature of the work. Potentially high asbestos exposure activities are classified as Class I asbestos work. As the potential for exposure decreases, so does the work classification. Therefore, Class IV asbestos work has the lowest potential for asbestos exposure.

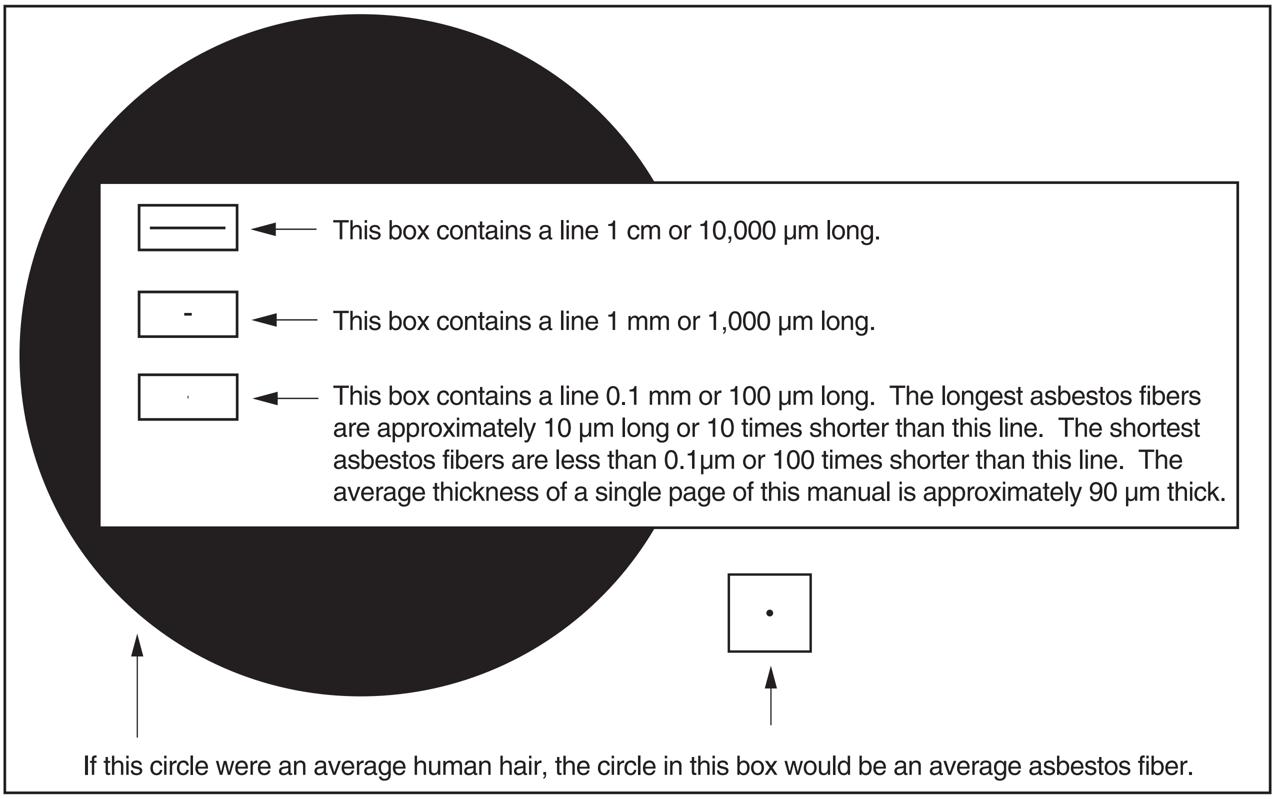

Figure 1-1. Size comparison between an asbestos fiber and a human hair.

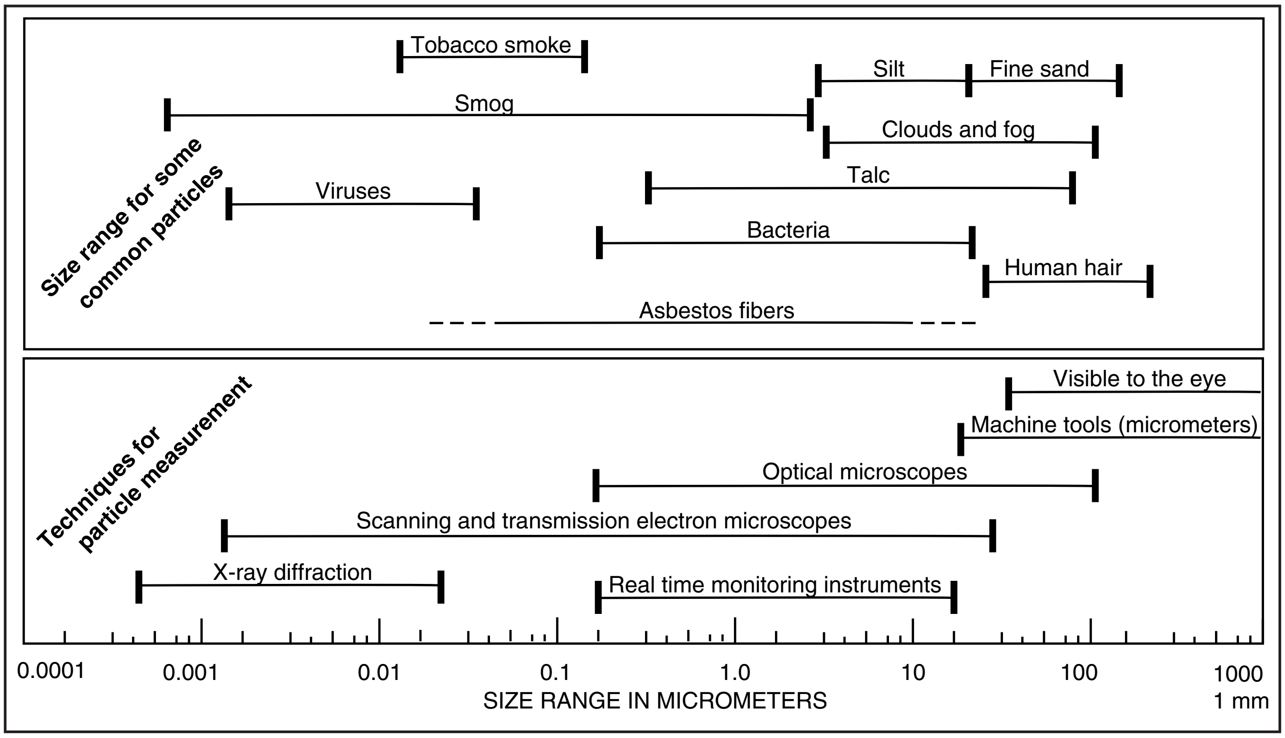

Figure 1-2. Size comparison between asbestos and other substances and common measurement techniques.

Class I Asbestos Work

Class I asbestos work are activities involving the removal of sprayed-on or troweled-on SMs and TSI materials.

Examples of activities involving SMs include removing:

- Decorative plaster on ceilings
- Acoustical material on decking
- Fireproofing material on structural members

Examples of TSI materials activities include removing insulation from:

- Pipes
- Boilers
- Tanks
- Ducts

Based on records from past asbestos abatement jobs, OSHA has found that SMs and TSI materials have the highest likelihood of releasing fibers when disturbed. For this reason, OSHA requires rigorous control methods when performing this type of work.

Class II Asbestos Work

Class II asbestos work involves removal of any other type of ACM that is not SM or TSI material. Examples of Class II asbestos work involve the removal of materials such as:

- Floor tiles
- Siding
- Roofing
- Transite panels

OSHA does not consider the risk in handling these materials as high as Class I asbestos work because all of these materials are nonfriable.

Class III Asbestos Work

Class III asbestos work involves repair and maintenance activities involving intentional disturbance of ACM or PACM. An intentional disturbance occurs when the worker must remove or disturb the material in order to perform a particular work function. For example, if a worker has to repair a valve covered with TSI materials, it would be considered Class III asbestos work because removal of the insulation around the valve is necessary so the valve can be repaired.

Class III asbestos work is limited to intentional cutting away of small amounts (less than a single standard waste bag) of ACM or PACM to perform a repair or maintenance activity.

Class IV Asbestos Work

Class IV asbestos work is maintenance and custodial activities when workers can come in contact with ACM or PACM. Specific work activities include:

- Dusting surfaces
- Vacuuming carpets
- Mopping floors

Workers performing Class IV activities may also come in contact with ACM or PACM when performing a wide variety of routine jobs that result in an incidental disturbance of ACM or PACM. An incidental disturbance is when a worker does not intentionally disturb the material, but does so accidentally. The following are examples of the type of activities that may cause incidental disturbances of ACM or PACM:

- Changing a battery in a smoke detector attached to a ceiling containing asbestos.

- Polishing floors that contain asbestos.

- Changing a light bulb in a fixture attached to an ceiling containing asbestos.

SECTION 1 - ASSIGNMENT SHEET

1. Define the following terms and acronyms:

   ACM ____________________

   EPA ____________________

   Asbestos fiber ____________________

   Friable asbestos-containing material ____________________

   ____

   Micron ____________________

   Nonfriable asbestos-containing material ____________________

   ____

   OSHA____________________

   PACM____________________

   PEL ____________________

   SM ____________________

   TSI ____________________

2. List the six types of asbestos fibers as defined by OSHA.

   ____

   ____

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3. List the two most common types of asbestos used in construction.

   ____

   ____

4. Explain the difference between friable and nonfriable asbestos-containing materials.

5. Give the OSHA permissible exposure limit for asbestos. ____________________

6. Describe a Class I asbestos work activity.

7. Describe a Class II asbestos work activity.

8. Describe a Class III asbestos work activity.

9. Describe a Class IV asbestos work activity.

Section

2

ASBESTOS ABATEMENT WORKER REFRESHER

Title

HEALTH EFFECTS OF ASBESTOS

2

TRAINEE OBJECTIVES

After completing Section 2, you will be able to:

1. Define the following terms:

   Carcinogen
   Ingestion
   Inhalation
   Latency period
   Routes of entry
   Synergism

2. Identify the two major routes of entry for asbestos into the body.

3. Explain the relationship between smoking and exposure to asbestos.

4. List the four diseases linked to occupational asbestos exposure and the symptoms of each disease.

5. Name the body organs affected by asbestos exposures, and explain how asbestos affects each one.

6. List the three protective mechanisms the body uses to rid itself of asbestos fibers, and explain how these mechanisms work.

INTRODUCTION

The earliest death directly related to asbestos was recorded in England in 1907. Studies of factory workers in 1930 indicated that 26 percent of the workers were affected from exposure to asbestos in varying degrees.

Although some asbestos-related health problems were studied and documented many years ago, the problems went unchecked and unsolved until recently. There were various reasons for the delay, such as:

- Lack of available information
- Ignorance by the public, industry, and workers
- Lack of awareness of various agencies by the public
- Intentional withholding of information

ROUTES OF ENTRY

In general, asbestos fibers enter the body in two ways called *routes of entry*:

1. Ingestion
2. Inhalation

Ingestion

Ingestion is the act of taking substances into the body by eating and drinking. Most asbestos fibers pass through the digestive tract unabsorbed if the exposure is small. However, when a large exposure occurs, significant amounts of fibers are absorbed. Asbestos fibers ingested in large amounts may cause the following:

- Tumors in various parts of the body
- Cancer in the colon, spleen, and other areas of the body

Inhalation

Inhalation is the act of taking substances into the body by inhaling (or breathing). Inhalation is the most common route of entry and is the most dangerous way to be exposed to asbestos fibers.

Fibers small enough to reach the deepest part of the lung are called *respirable* fibers. The size of a respirable fiber is from 25 microns to less than 0.01 microns. A *micron* is about 1/20,000 of an inch or 1/1,000,000 of a meter. These fibers are too small to be seen by the naked eye.

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Once respirable fibers become imbedded in the lung, problems begin. Unlike many particles, these small fibers cannot be cleared from the lung. Generally, dust and other inhaled materials are worked up from the lung and coughed out. Many substances and chemicals can be changed or detoxified by the body's defenses. This is particularly true with the tars from cigarette smoke. For example, if an individual quits smoking for two years, most of the damaging chemicals are detoxified during that time, and the chance of getting cancer is reduced by half.

Respirable fibers escape these mechanisms and do not become detoxified over time. An asbestos fiber is a mineral, similar to sand or glass. It stays in the lungs unchanged, indefinitely.

How the Lungs React to Foreign Particles

The main functions of the lungs are to:

- Bring oxygen into the body
- To get rid of carbon dioxide produced by the body

As the air is inhaled, the hairs in the nose filter out large particles. The remaining air and small particles of dust and debris continue through the pharynx, trachea, and then into the two bronchial tube branches (Figure 2-1).

Each bronchial tube branches out similar to a tree. The branches become smaller and smaller, ending in air sacs or *alveoli*. Oxygen is picked up by the blood in the alveoli, and carbon dioxide is left in the alveoli to be expelled.

Cough

The bronchi and trachea are so sensitive that any foreign matter that comes in contact with them produces an irritation that results in a cough. The rapidly moving air generated by a cough usually carries with it any debris or particles present in the bronchi or trachea.

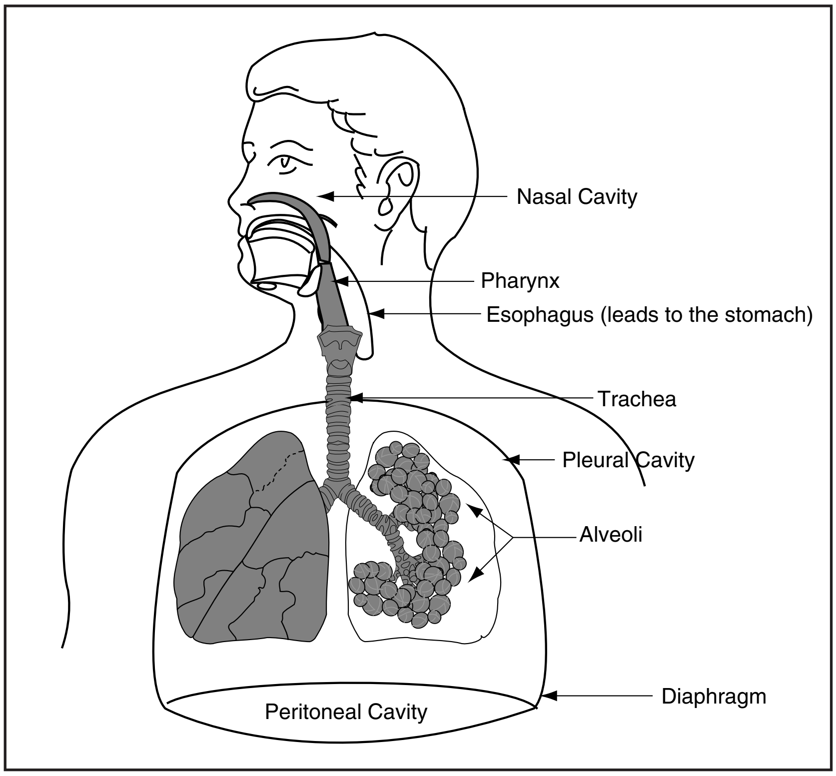

Figure 2-1. The respiratory system begins at the nasal cavity and continues to the alveoli.

Cilia

Another protective mechanism involves the cells lining the inside of the trachea and lungs. These cells contain small mucus coated hairs called *cilia.* The cilia beat toward the pharynx, moving the mucus upward in a continually flowing sheet. If particles implanted on the trachea or lungs have not caused an irritation, the particles are moved in this mucous sheet back to the pharynx where the particles are swallowed into the stomach and then expelled.

Immune System

The body's own immune system helps keep small particles from reaching the deep lung, which includes the bronchioles and alveoli. Large mobile white blood cells known as *macrophages* are activated when dust particles implant in the deep lung. The macrophages surround the particles and try to digest them using strong acids or enzymes. However, macrophages are not capable of digesting asbestos fibers.

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ASBESTOS-RELATED DISEASES

According to information gathered in various asbestos studies, the following diseases are linked with occupational asbestos exposure:

- Asbestosis
- Cancers
- Pleural disease

Asbestosis

Asbestosis is the most common noncancerous disease found among workers who have been exposed to large doses of asbestos fibers over a long period of time.

Once asbestos fibers are deposited in the bronchioles and alveoli, the body sends out macrophages to destroy the asbestos fibers. However, the macrophages are not able to digest the inhaled fibers and may burst open, releasing enzymes that can break down the lung tissue. This process results in tough, inelastic, noncancerous scar tissue on the lungs. Scar tissue clogs the lungs, prevents oxygen transfer, and makes breathing difficult and painful. The scarring process is usually long and slow. In general, health problems do not appear until 15 years after the first exposure. However, the scarring of the lungs may appear in four or five years if the exposure is heavy.

The following are symptoms of asbestosis:

- Shortness of breath on exertion
- Tightness in the chest
- Pain in the chest
- Dry cough
- Shallow, rapid breathing
- Loss of appetite
- Dry crackling sounds in the lungs while breathing

The most characteristic symptom of asbestosis is the dry crackling sounds heard in the lungs when an individual is breathing. These sounds are called rales. As lung scarring progresses, rales becomes worse.

Asbestosis is a progressive disease, which means it continues to get worse. Asbestosis shortens an individual's life and increases the risk of death from pneumonia and other respiratory diseases. In most cases, asbestosis kills its victims within 15 years after the onset of symptoms. The causes of death from asbestosis-related diseases include:

- Heart failure
- Respiratory infections
- Lung cancer

Cancers

Asbestos, unlike many of the products or materials that are suspected of causing cancer, is a known human *carcinogen*. Asbestos was one of the first six substances studied proven to be a human carcinogen.

Lung Cancer

Lung cancer is the most common cancer found among asbestos workers. Lung cancer is a life-threatening, invasive growth or tumor in the lungs.

It is believed that exposures as short as one month can cause asbestos-induced lung cancer. However, because it takes 20 to 30 years for asbestos-induced lung cancer symptoms to become evident, many exposed workers could be thinking “It isn’t dangerous. I’ve worked with it for years. I’m okay.”

The risk for developing lung cancer is greater among smokers. When a worker smokes and is also exposed to asbestos fibers, that person is 50 times more likely to contract lung cancer than a person in the normal population.

The following are symptoms of lung cancer:

- Cough or change in cough habit
- Chest pain

Pleural and Peritoneal Mesothelioma

If asbestos fibers come in contact with the linings or membranes of the chest, abdominal cavity, or diaphragm, a cancer known as *mesothelioma* can develop. Mesothelioma spreads rapidly, and its only cause is asbestos exposure.

Asbestos fibers pass right through the soft lung tissues to the lining of the lung and abdominal cavity, where they remain and trigger the cancerous growth. The cancer may grow outward through the chest wall, or it can spread into the bones, lymph glands, and area between the lungs. The abdominal and chest cavities can become filled with cancerous masses and organs can be crushed or cut off from the rest of the body.

Pleural mesothelioma is a malignant (cancerous) tumor that spreads rapidly throughout the cells of the chest lining. *Peritoneal mesothelioma* is cancer of the abdominal cavity lining. Breathing is not possible without the pleural lining. Both these cancers are extremely rare, but asbestos is the only known cause of mesothelioma. It is always fatal, generally within one year after the diagnosis of the disease. Currently, no successful treatment is known for this disease.

The following are symptoms of mesothelioma:

- Cough
- Pain in the chest wall
- Shortness of breath
- Weight loss

Gastrointestinal Cancers

Gastrointestinal cancers are linked to the ingestion of asbestos material. Ingestion of asbestos can occur by swallowing asbestos-contaminated food and beverages or inhaling or swallowing airborne asbestos fibers. The potential for developing digestive system cancers is increased for asbestos workers. Some of these cancers include cancer of the esophagus, stomach, colon, and pancreas.

Pleural Diseases

Pleural diseases exist in the *pleura*, the membrane encasing the lungs and lining the walls of the thoracic cavity. There are three types of benign, or non-cancerous, pleural diseases that are related to asbestos exposure:

- Pleural plaque
- Pleural thickening
- Pleural effusion

Pleural Plaque

Pleural plaque is a calcified or hardened formation located on the pleural lining of the chest wall. The calcified plaque shows up on a routine chest x-ray as an uneven thickness along the outside and lower edges of the lung lining.

Pleural Thickening

If asbestos fibers move from the lung to the pleura, the pleura can thicken and fibrosis can develop. This thickening can restrict the ability of the lungs to expand and contract and, therefore, breathing becomes difficult. Pleural thickening can place you at risk of developing other, more serious chest diseases.

Pleural Effusion

Asbestos-related pleural effusion is a build-up of fluid in the pleural space. Some effusions cause chest pains, but others do not. Pleural effusion is treatable. Persons with this disease should be vigilant about their respiratory health.

Latency Periods

The period between when initial exposure occurs and the onset of disease is the *latency period.* Once exposed to airborne asbestos, signs and symptoms of the diseases may not appear until 10 to 40 years after the initial exposure.

Asbestosis usually has a latency period of 15 to 30 years. However, the greater the exposure to airborne asbestos, the shorter the latency period for asbestosis.

Mesothelioma has a latency period of approximately 30 to 40 years, although it has appeared as soon as 15 years after the first exposure. Unlike the other asbestos diseases, mesothelioma has a wide, not clearly defined latency period. However, most occupational physicians agree that pleural mesothelioma has the longest latency period of all asbestos-related diseases. This type of cancer can take 10 to 40 years to develop.

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RISK FACTORS FOR ASBESTOS-RELATED DISEASES

Usually, the higher the exposure level and longer the duration of exposure to airborne asbestos fibers, the greater the risk of developing asbestosis, lung cancer, mesothelioma, and gastrointestinal cancers. No level of exposure is safe. The best protection is to avoid exposure to asbestos fibers.

There are several factors that determine an individual's risk of developing an asbestos-related disease. These factors include:

- Occupation
- Level of exposure
- Smoking habits

Occupation

The adverse health effects associated with asbestos exposure have been studied extensively for many years. It became evident that many asbestos workers died—workers who were exposed to asbestos while working at a job site. Asbestos workers develop lung cancer 10 to 20 times more often than other individuals. Workers exposed to asbestos die of lung cancer at a much higher rate than the unexposed population.

Level of Exposure

Today, asbestos abatement workers follow specific work practices, and wear appropriate protection. Respirators help minimize the risk of exposure to workers. However, asbestos exposures at work have caused significant health effects to the household members of workers who have not taken the proper precautions. Asbestos fibers can be brought home on the workers' skin and clothing or on their equipment, such as a lunch box or automobile. The asbestos fibers can then spread easily to others in the household.

Smoking Habits

Asbestos is a carcinogen. Asbestos fibers by themselves have been known to cause tumors in numerous tissues. In addition, asbestos is a *cocarcinogen*. It reacts with other carcinogens by multiplying their effects and making the effects more deadly. This reaction is called *synergism*. For example, asbestos workers who smoke cigarettes have a 50 to 90 times greater risk of getting lung cancer than nonsmoking asbestos workers.

Why are individuals who smoke at a higher risk of developing lung cancer? One reason may be that smoking temporarily paralyzes the cilia located in the trachea and lungs, which normally sweep some portion of the asbestos fibers upwards, removing them from the lungs. Smoking may allow more asbestos particles to reach deep into the lungs, thereby increasing a smoker's risk.

Lung cancer is caused by many agents, the most common being cigarette smoke. Agents, such as asbestos or cigarette smoke, can cause a malignant growth or tumor in the lung tissue. The relationship between smoking and asbestos exposure is shown in Figure 2-2. (The numbers on the left represent the increased chances of an individual contracting cancer. They do not represent increased percentages.)

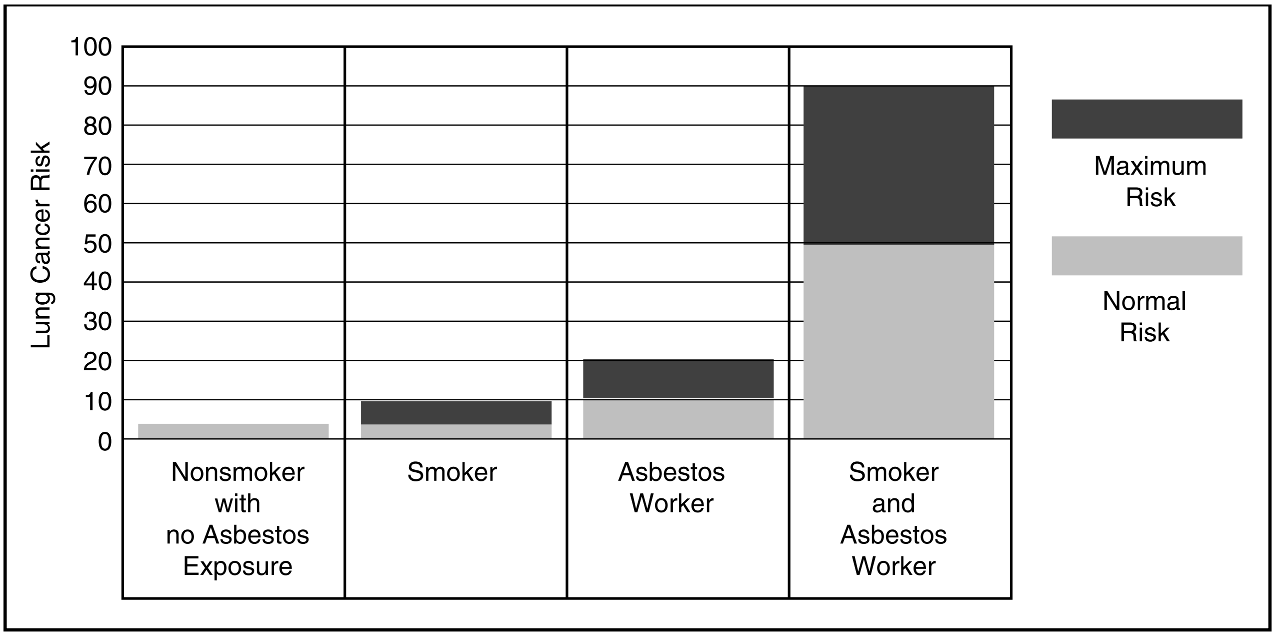


Figure 2-2. Lung cancer risk significantly increases among asbestos workers and smokers.

2

REDUCING THE RISK OF ASBESTOS-RELATED DISEASES

To reduce health risks associated with occupational exposures to asbestos, Occupational Safety and Health Administration (*OSHA*) lowered the permissible exposure limit (*PEL*) from 2.0 fibers per cubic centimeter (f/cc) 8-hour time weighted average (*TWA*) to 0.2 f/cc 8-hour TWA on July 21, 1986. OSHA found that by reducing the PEL, it could reduce the asbestos cancer mortality risks from 64 deaths per 1,000 workers to 7 deaths per 1,000 workers.

On August 10, 1994, OSHA again lowered the PEL for occupational exposure to asbestos from 0.2 f/cc to 0.1 f/cc 8-hour TWA. OSHA expects that this reduction in the PEL will further reduce the mortality rate to 3.4 deaths per 1,000 workers.

Asbestos-related diseases can also be reduced by:

- Avoiding unnecessary asbestos exposure
- Wearing the proper personal protective equipment (*PPE*)
- Following the proper asbestos work procedures
- Not smoking

Because the risk of asbestos-related diseases is increased by smoking cigarettes, it is extremely beneficial to quit smoking, both on and off the job. Table 2-1 provides smoking cessation program information.

The symptoms of asbestos-related diseases may not become apparent for many decades after exposure. If any of the following symptoms develop, consult a physician as soon as possible.

- Shortness of breath
- Cough or change in cough pattern
- Blood in the sputum (fluid) coughed up from the lungs
- Pain in the chest or abdomen
- Difficulty in swallowing or prolonged hoarseness
- Significant weight loss

Table 2-1. The following organizations provide smoking cessation information and program material.

The National Cancer Institute

The National Cancer Institute operates a toll-free Cancer Information Service (CIS) with trained personnel to help you. Call 1-800-4-CANCER to reach the CIS office serving your area or write to the Office of Cancer Communications; National Cancer Institute; National Institutes of Health; Building 31, Room 10A24, Bethesda, Maryland 02892. In Hawaii, on Oahu call 524-123 (call collect from neighboring islands). Spanish-speaking staff members are available during daytime hours to callers from the following areas: California, Florida, Georgia, Illinois, New Jersey (area code 201), New York, and Texas. Consult your local telephone directory for listings of local chapters.

American Cancer Society

The American Cancer Society (ACS) is a voluntary organization composed of 58 divisions and 3,100 local units. ACS helps people learn about the health hazards of smoking and becoming successful exsmokers through "The Great American Smoke Out" in November, the annual Cancer Crusade in April, and numerous educational materials. Write to the American Cancer Society; 3340 Peachtree Road, N.E.; Atlanta, Georgia 30062 for information, or call (404) 320-3333.

American Heart Association

The American Heart Association (AHA) is a voluntary organization with 130,000 members (physicians, scientists, and laypersons) in 55 states and regional groups. AHA produces a variety of publications and audio-visual materials about the effects of smoking on the heart. AHA also has developed a guidebook for incorporating a weight control component into smoking cessation programs. Write to the American Heart Association; 7320 Greenville Avenue; Dallas, Texas 75231 for information, or call (214) 750-5300.

American Lung Association

The American Lung Association (ALA) is a voluntary organization of 7,500 members (physicians, nurses, and laypersons). It conducts numerous public information programs about the health effects of smoking. ALA has 59 state and 85 local units. The organization actively supports legislation and information campaigns for nonsmokers' rights and provides help for smokers who want to quit; for example, through "Freedom From Smoking," a self-help smoking cessation program. For information write the American Lung Association; 1740 Broadway; New York, New York 10019, or call (212) 245-8000.

Office on Smoking and Health, United States Department of Health and Human Services

The Office on Smoking and Health (OSH) is the Department of Health and Human Services' lead agency in smoking control. OSH has sponsored distribution of publications on smoking-related topics, such as free flyers on relapse after initial quitting, helping a friend or family member quit smoking, and the effects of parental smoking on teenagers. For additional information, write The Office on Smoking and Health; United States Department of Health and Human Services; 5600 Fishers Lane; Park Building, Room 110; Rockville, Maryland 20857.

2

SECTION 2 - ASSIGNMENT SHEET

1. Define the following terms:

   Carcinogen ____

   Ingestion ____

   Inhalation ____

   Latency period ____

   Routes of entry ____

   Synergism ____

2. Identify the two major routes of entry for asbestos into the body.

   ____

3. Explain the relationship between smoking and exposure to asbestos.

   ____

4. List the four diseases linked to occupational asbestos exposure and the symptoms of each disease.

5. Name the body organs affected by asbestos exposures, and explain how asbestos affects each one.

6. List the three protective mechanisms the body uses to rid itself of asbestos fibers, and explain how these mechanisms work.

Section
3

ASBESTOS ABATEMENT WORKER REFRESHER

Title

MEDICAL MONITORING AND SURVEILLANCE

TRAINEE OBJECTIVES

After completing Section 3, you will be able to:

1. Define the following acronyms:

   FEV_1
   FVC
   NIOSH
   PFT

2. List the three reasons for establishing a medical monitoring and surveillance program.
3. List the five required elements of an initial/preplacement examination.
4. List the five required elements of an annual examination.
5. List two additional recommended tests.
6. State the number of years an employer must keep medical records of each employee.

3

MEDICAL MONITORING AND SURVEILLANCE PROGRAM

A good medical surveillance program helps protect the safety and health of the workers. Employers should have a thorough understanding of Occupational Safety and Health Administration (*OSHA*) and state requirements regarding medical surveillance programs for their employees who are exposed to asbestos or who wear respirators as part of their job. The monitoring and surveillance program shall be provided at no cost to the employee and shall be administered at a reasonable place and time.

With the implementation of a good medical monitoring and surveillance program, asbestos abatement contractors will be able to:

- Verify every worker's medical status periodically.
- Comply with OSHA, Environmental Protection Agency (*EPA*), and state standards and regulations on medical surveillance of workers exposed to asbestos.
- Reduce their liability risks.

OSHA Asbestos Standard for Construction

The OSHA Asbestos Standard for Construction, 29 *CFR* 1926.1101, requires that asbestos abatement contractors have a written medical monitoring and surveillance program under the supervision of a licensed physician. The program must include both an initial/preplacement examination and an annual examination. 29 CFR 1926.1101 also outlines the requirements for maintaining medical records for every asbestos abatement worker.

The medical examination is used to document information for each asbestos worker, including:

- Baseline health status. (The worker's health status before work begins.)
- Health status during employment.

MEDICAL EXAMINATIONS

Under Standard 29 CFR 1926.1101, employers must institute a medical surveillance program for all employees who work for an overall total of 30 or more days per year and are:

- Engaged in Class I, II, or III asbestos work.
- Exposed to asbestos at or above the *permissible exposure limit* (*PEL*).
- Exposed to asbestos at or above the *excursion limit* (*EL*)
- Required to wear a negative pressure respirator in the performance of work in any of the above mentioned circumstances.

Initial/Preplacement Medical Examination

3

Initial/preplacement medical examinations are required when a worker who will be exposed to asbestos starts a job. According to Standard 29 CFR 1926.1101, "the employer must ensure all medical examinations and procedures are performed by or under the supervision of a licensed physician. Medical examinations are to be provided at no cost to the employee and be provided at a reasonable time and place."

"Medical examinations and consultations must be provided to each employee according to the following schedule:

- Prior to assignment of the employee to an area where negative pressure respirators are worn.
- When the employee is assigned to an area where exposure to asbestos may be at or above the PEL for 30 or more days per year.
- Medical examinations must be given within 10 working days following the 30th day of exposure.
- If the examining physician determines that any of the examinations should be provided more frequently than specified, the employer must provide such examinations to affected employees at the frequencies specified by the physician."

There is one exception to the initial/preplacement medical exam OSHA requirement. Standard 29 CFR 1926.1101 states:

> No medical examination is required of any employee if adequate records show that the employee has been examined in accordance to the above schedule within the past one-year period.

An initial/preplacement medical examination includes the following elements:

- Medical/work history and respirator disease questionnaire (See sample in Regulations.)
- Physical exam
- Chest x-ray(s)
- Pulmonary function tests (*PFTs*) (breathing tests)
- Miscellaneous tests

Annual Medical Examination

Employers must provide a comprehensive annual medical examination to every worker engaged in Class I, II, or III asbestos work.

As in the initial/preplacement medical examination, the annual examination must be performed by a licensed physician and must include the shortened standardized medical questionnaire.

An annual medical examination includes the following elements:

- Abbreviated medical/work history and respirator questionnaire (See sample in Appendix.)
- Physical exam
- Chest x-ray(s)
- Pulmonary function tests (breathing tests)
- Miscellaneous tests

The medical tests given during the initial/preplacement are necessary for establishing the status of a worker's health before asbestos work begins. Annual examinations are required to evaluate any change in the worker's health due to past and continuing asbestos work. A description of the required elements follow.

Medical/Work History and Respirator Disease Questionnaire

All workers must complete a medical/work history and respirator questionnaire. Workers should include any past or present respiratory, heart, or digestive tract diseases, as well as the sources of exposures. Several questions relate to chronic lung diseases, while others address the worker's personal habits, such as smoking.

In the Standard 29 CFR 1926.1101, Appendix D, there is a questionnaire that must be given to all workers who are exposed to asbestos above the action level. (A copy of the Standard 29 CFR 1926.1101 is reproduced in its entirety in Regulations section of this manual.) A physician uses the completed questionnaire to determine the risk to a worker while wearing respiratory protection.

Physical Examination

A complete physical examination must be performed by or under the supervision of a licensed physician. The physical examination must include a standardized questionnaire. The questionnaire in Part I of Appendix D of the Standard 29 CFR 1926.1101 must be used for initial/preplacement examinations. For annual examinations, the shortened questionnaire in Part II of Appendix D of the Standard 29 CFR 1926.1101 for Construction must be used. In both instances, a form as equally detailed as the OSHA form may be substituted.

It is a good practice to require workers over the age of 40, or other individuals with increased risk, to have physical examinations that include electrocardiogram. Use of a respirator may increase strain on the heart. If an abnormality is indicated on the electrocardiogram, appropriate action can be taken, such as a job transfer to a position that does not require use of a respirator.

Routine physical examinations often include the following:

- Medical history
- Blood pressure check procedures
- Pulse check
- Vision test (depth perception and peripheral vision)
- Audiogram (hearing test)
- Urinalysis
- Follow-up classification with appropriate recommendations

The results of the initial physical examination are used as the baseline of a worker's health. In some cases, the worker may not be able to wear a respirator due to an underlying health problem.

Before the medical examination, the employer must give the examining physician the following:

- A copy of Standard 29 CFR 1926.1101, and Appendices D, E, G, and I.
- A description of the employee's duties relating to asbestos exposure.
- The exposure level or anticipated exposure level.
- A description of any PPE, including respiratory equipment that is or may be used.
- Information from any previous medical examinations.

After the medical examination, the employer must obtain a written opinion from the physician. It must contain the results of the examination and the physician's opinion as to whether the worker has detected any medical conditions that would place the worker at an increased risk from exposure to asbestos. The opinion must also include:

- Any recommended limitations on the worker or use of personal protective equipment, such as respirators.
- A statement that the physician has informed the worker of the medical examination results.

The physician is prohibited from revealing in the written opinion specific findings or diagnoses unrelated to occupational exposure to asbestos.

After receiving the written opinion from the examining physician, the employer must give the worker a copy within 30 days. All workers, particularly those who move from employer to employer, should be encouraged to obtain and keep copies of their medical records or have all medical records sent to their occupational or family physician.

The physician can compare the annual examination to the initial/preplacements examination to see if there are any changes in a worker's health. If there are noticeable changes, the employer and employee should both be notified so that immediate corrective actions may be taken. For example, a worker may need to transfer to another job assignment or stop using a respirator.

Chest X-Rays

OSHA regulations require that the interpretation and classification of chest x-rays shall only be performed by a certified B-reader, board eligible/certified radiologist, or an experienced physician with expertise in *pneumoconiosis*. (Pneumoconiosis is any of a group of chronic lung diseases caused by the inhalation of dust particles.) B-readers are physicians who have received specialized training in the interpretation of chest x-rays, specifically relating to occupational lung diseases. B-readers are required to pass a test administered by the National Institute for Occupational Safety and Health (*NIOSH*) in order to be certified.

The frequency of chest x-rays depends on the worker's age and the number of years of exposure to asbestos. Normally, chest x-rays are taken only when the examining physician decides they are necessary. Some physicians recommend chest x-rays once every five years depending upon the worker's age. Table 3-1 shows how often chest x-rays should be taken.

Pulmonary Function Tests

A *pulmonary function test* (*PFT*) determines if the lungs are expanding and contracting normally and if there is enough air moving into and out of the lungs. They must be performed by a licensed physician or by a NIOSH-certified technician. PFTs are conducted with a spirometer. The following tests are included in PFTs:

- Forced vital capacity
- Forced expiratory volume in one second

Table 3-1. This table shows how often chest x-rays should be taken of workers who have been exposed to asbestos.

Years Since First Exposure	Age of Employees		
	18 to 35	35+ to 40	45+
0 to 10	Every 5 years	Every 5 years	Every 5 years
10+	Every 5 years	Every 2 years	Every 1 year

The *forced vital capacity (FVC)* test measures the maximum amount of air that can be forced out of the lungs after inhaling fully.

The *forced expiratory volume at one second (FEV_1)* test measures the amount of air that can be forced out of the lungs in one second after inhaling fully.

If the FVC and the FEV_1 are reduced, this may be a sign of a possible problem in a worker's lungs.

3

Miscellaneous Tests

There are two recommended tests that are beneficial in detecting problems arising from the ingestion of asbestos fibers:

- Sputum cytology
- Occult stool

A sputum (expectorated saliva and mucus) sample is taken for sputum cytology. Cytology is the branch of biology dealing with cells. Sputum cytology studies the cells expectorated from the lungs, bronchi, and trachea. The origin, structure, and function of cells are studied to determine if abnormalities exist.

A stool (feces) sample is taken for occult stool. Occult stool studies the function and cells associated with the stomach and intestines.

MEDICAL RECORDKEEPING

According to Standard 29 CFR 1926.1101, the physician must inform workers of the examination results, and provide the employer with a written report of the results. Only information relative to the worker's exposure can be contained in the written report. Therefore, the physician cannot inform the employer about information that is not related to asbestos exposure.

The employer must also give a copy of the report to the employee within 30 days of receipt. If an employee or an employee's representative requests in writing a copy of any additional medical records, the employer must provide the copy within 15 days of notification.

Any employee who has had a medical examination within the last year does not have to undergo another examination if he or she begins work for a new employer. As a rule, the results of the medical examination are valid for one year, unless the examining physician feels that additional monitoring is necessary. If the employee presents the new employer with copies of his or her current medical records, the employee is not required to be examined again before starting work.

The employer must keep each employee's medical record for the duration of the employee's employment, plus 30 years. Normally, the test results are kept on file by the physician or clinic.

Access to Employee's Medical Record

An employee's medical record must be made available to:

- The employee.
- All individuals having specific written consent of the employee.
- Certain state and federal agencies, under OSHA Access to Medical and Exposure Records Standard, 29 CFR 1926.33.

Employers must inform employees that their medical records are available to them under the 29 CFR 1926.33. Employees have the right to see or copy their medical records.

SECTION 3 - ASSIGNMENT SHEET

1. Define the following acronyms.

   FEV_1 ______________________________

   FVC ______________________________

   NIOSH ______________________________

   PFT ______________________________

2. List the three reasons for establishing a medical monitoring and surveillance program.

   ____

   ____

   ____

   ____

3. List the five required elements of an initial/preplacement examination.

   ____

   ____

   ____

   ____

   ____

   ____

4. List the five required elements of an annual examination.

   ____

   ____

   ____

   ____

   ____

   ____

5. List two additional recommended tests.

____

____

6. State the number of years an employer must keep medical records of each employee.

____

ASBESTOS ABATEMENT WORKER REFRESHER

Section
4

Title
LEGAL RIGHTS OF WORKERS AND ASBESTOS ABATEMENT REGULATIONS

TRAINEE OBJECTIVES

After completing Section 4, you will be able to:

1. List ten legal rights workers have under the Occupational Safety and Health Act of 1970.

2. List the seven responsibilities workers have under the Occupational Safety and Health Act of 1970.

3. List seven steps workers should follow if they are punished for exercising any OSHA legal right.

4

THE OCCUPATIONAL SAFETY AND HEALTH ACT OF 1970

The Occupational Safety and Health Act of 1970 (*OSH Act*) is the most significant labor-protective statute for health and safety in the workplace. The Occupational Safety and Health Administration (*OSHA*) encourages employers and workers to work together so that workplace hazards can be reduced. This act was created by OSHA within the Department of Labor.

Responsibilities of Individuals

Under OSHA's Construction Standard, certain rules must be followed by management, employers, designated competent persons, and workers to ensure safety on the construction site.

Management

Under OSHA's Construction Standard, a senior member of management must initiate a written job site safety and health program and designate a competent person to maintain the program as required by 29 *CFR* 1926.1101.

Employers

Under OSHA's Construction Standard, all employers, general contractors, and subcontractors must maintain a written job site safety and health program by designating competent persons to carry out the job site safety and health program.

Employers are in violation of OSHA standards if competent persons are not designated to implement the job site safety and health program requirements.

The following is an excerpt from the General Duty Clause of the OSH Act:

Sec. 5(a) Each employer:
(1) Shall furnish to each of his employees: employment and a place of employment which are free from recognized hazards that are causing or are likely to cause death or serious physical harm to his employees;

(2) Shall comply with occupational safety and health standards promulgated under this Act.

Competent Persons

The OSHA Asbestos Standard for Construction 29 CFR 1926.1101 requires a competent person on all asbestos jobs. Under this standard, "competent person" means, in addition to the definition in 29 CFR 1926.32 (f), one who:

- Is capable of identifying existing asbestos hazards in the workplace.
- Is capable of selecting the appropriate control strategy for asbestos exposure.
- Has the authority to take prompt corrective measures to eliminate them, as specified in 29 CFR 1926.32(f).

In addition, for Class I and Class II asbestos work, a competent person is one who is specially trained in a training course, which meets the criteria of the Environmental Protection Agency's (*EPA's*) Model Accreditation Plan (40 CFR 763) for project designer or supervisor, or its equivalent.

For Class III and Class IV asbestos work, a competent person is one who is trained in an operations and maintenance course developed by EPA [40 CFR 763.92 (a)(2)].

Specific Duties of Competent Persons

Competent persons on asbestos jobs are required to perform frequent and regular inspections of the job site, materials, and equipment.

Specifically, OSHA regulations require the competent person to perform on-site inspections at the following times:

- Class I asbestos work – At least once during each work shift, and at any reasonable time a worker requests an on-site inspection.
- Class II and Class III asbestos work – At intervals sufficient to assess whether conditions have changed, and at any reasonable time a worker requests an on-site inspection.

On all work sites where workers are engaged in Class I or Class II asbestos work, the designated competent person shall perform or supervise the following duties, as applicable:

- Set up the regulated area, enclosure, or other containment.
- Ensure (by on-site inspection) the integrity of the enclosure or containment.
- Set up procedures to control entry to and exit from enclosure and/or work area.
- Supervise worker exposure monitoring and ensure that it is being conducted properly.
- Ensure that employees working within the enclosure and/or using glove bags wear protective clothing and respirators.
- Ensure (by on-site supervision) that workers set up and remove engineering controls, and use work practices and personal protective equipment (*PPE*) in compliance of all regulations.
- Ensure that workers use the hygiene facilities and observe the decontamination procedures.
- Ensure (by on-site inspection) that engineering controls are functioning properly and workers are using proper work practices.

Employees

Under OSHA's Construction Standard, employees are responsible for:

- Reading the OSHA poster at the job site.
- Complying with all applicable OSHA standards.
- Following all safety and health rules and regulations and use the required PPE while working.
- Wearing or using prescribed PPE when working.
- Reporting hazardous conditions to the supervisor.

- Reporting any job-related injury or illness to the employer and getting treatment promptly.
- Cooperating with the OSHA Compliance Officer conducting the inspection about the health and safety conditions at the workplace.
- Exercising their rights under the OSH Act in a responsible manner.

Although OSHA does not cite employees for violations of their responsibilities, all employees "shall comply with all occupational safety and health standards and all rules, regulations, and orders issued under the Act" that are applicable.

The following is a small excerpt from the OSH Act:

Sec. 5(b) Each employee shall comply with occupational safety and health standards and all rules, regulations and orders issued pursuant to this Act which are applicable to his own actions and conduct.

LEGAL RIGHTS OF WORKERS

Under the OSH Act, workers have many legal rights on the job site including:

- Have an employee representative
- Review standards and regulations
- Access medical and exposure records
- Request safety and health hazard information
- Review the Log and Summary of Occupational Injuries (Form 200)
- Request an OSHA inspection
- Help the OSHA compliance officer
- Observe monitoring and examine results
- Contest the abatement period
- Contact the National Institute for Occupational Safety and Health (*NIOSH*)
- Have knowledge of standard variances
- Report imminent danger
- Refuse dangerous work
- Report safety or health hazards
- Exercise their OSHA rights
- File a discrimination complaint

Exercise Their OSHA Rights

Section (11)(c) of the OSH Act was written to protect workers from discrimination or punishment for exercising their OSHA rights, such as:

- Complaining to their employer about job safety or health conditions.
- Discussing health or safety matters with other workers.
- Participating in union activities concerning health and safety matters.
- Participating in workplace health and safety committee activities.
- Filing health or safety grievances.
- Filing a complaint about workplace health or safety hazards with OSHA, state agencies, local health and fire departments, or any other government agency.
- Participating in OSHA inspections.
- Testifying before any panel, agency, or court about job hazards.
- Filing (11)(c) complaints.
- Providing evidence in connection with (11)(c) complaints.
- Refusing a dangerous task, but only under certain conditions.

Under Section (11)(c), employers cannot do any of the following if workers exercise their OSHA rights:

- Fire or demote workers
- Assign workers to undesirable jobs or shift
- Take away the seniority of workers
- Deny workers promotion
- Deny workers their earned benefits (e.g., sick leave, vacation time)
- Spy on workers
- Harass workers

- Blacklist workers with other employers
- Try to cut off the workers' credit at banks or credit unions

The following is a small portion of the OSH Act:

(11)(c)(1) No person shall discharge or in any manner discriminate against any employee because such employee has filed any complaint or instituted or caused to be instituted any proceeding under or related to this Act or has testified or is about to testify in any such proceeding or because of the exercise by such employee on behalf of himself or others of any right afforded by this Act.

(11)(c)(2) Any employee who believes that he has been discharged or otherwise discriminated against by any person in violation of this subsection may, within thirty days after such violation occurs, file a complaint with the Secretary alleging such discrimination. Upon receipt of such complaint, the Secretary shall cause such investigation to be made as he deems appropriate. If upon such investigation, the Secretary determines that the provisions of this subsection have been violated, he shall bring an action in any appropriate United States district court against such person. In any such action the United States district courts shall have jurisdiction, for cause shown to restrain violations of paragraph (1) of this subsection and order all appropriate relief including re-hiring of or reinstatement of the employee to his former position with back pay.

(11)(c)(3) Within 90 days of the receipt of a complaint filed under the subsection the Secretary shall notify the complainant of his determination under paragraph 2 of this subsection."

4

OSHA can only protect workers from punishment if it results from workers exercising their OSHA rights. OSHA cannot protect workers if they are disciplined solely for refusing to comply with OSHA regulations or valid health and safety rules established by their employer. If workers are not sure whether their OSHA rights have been violated, they should contact OSHA immediately.

Workers who wish to protest discrimination or punishment not related to their OSHA rights, must contact their union or the appropriate government agency.

File a Discrimination Complaint

Workers (or the employees' representative) have a right to file a Section 11(c) discrimination complaint if:

- They are being punished for exercising their rights.
- They are refusing to work when faced with an imminent danger of death or serious injury.
- There is insufficient time for OSHA to inspect the workplace, or file a Section 405 reprisal complaint under the Surface Transportation Assistance Act (*STAA*).

If workers believe that they have been discriminated against or punished for exercising a legal right, they should:

- Initiate a complaint within 30 days of punishment. Failure to do so may jeopardize the complaint. (It is best to initiate when the facts are fresh in the worker's mind.)
- Record the names (including witnesses) and addresses of the individuals involved.
- Explain what happened and when and where the incident occurred.
- Keep all relevant documents, letters, slips, etc.
- Record any other significant information.
- Contact OSHA in person or by letter or telephone.
- File a complaint in the nearest OSHA area office. (Workers do not have to fill out any forms. An OSHA representative fills out the form. A complaint may be filed by workers or the employees' representative.

COMPENSATION

In some instances, workers may be compensated for asbestos-related injuries or illnesses.

Workers' Compensation

Workers' compensation related to asbestos abatement may present several different problems. If workers suffer a traumatic injury on the job, the workers' compensation system of the state in which the workers are injured handles the claim the same as if the injury happened on a regular construction site. However, if workers suffer illnesses from exposure to substances on the asbestos abatement job site, there may be a problem in securing compensation because establishing the occupational nature of the disease is difficult under many workers' compensation statutes.

Some of these barriers result from poor administration of the statutes; others because the statute has limitations based on the last exposure, rather than when the disease was discovered.

The requirement under the Asbestos School Hazard Abatement Reauthorization Act of 1990 (*ASHARA*) and the OSHA regulations for maintenance of records of exposure, as well as medical surveillance, will help the workers secure workers' compensation if they suffer from an on-the-job exposure.

Personal Injury Actions (Toxic Tort)

Most of the injuries and illnesses suffered by workers on the job are compensatory only by workers' compensation claims. Employers are generally protected against any other legal action by workers (but not necessarily their families, if they suffer from the exposure of the worker).

Sometimes the actions of employers are so reckless that courts will award damages to workers for injury over and above the workers' compensation benefits. These cases against employers are very difficult to prove. However, in those situations where the employers acted in a way that was calculated to bring harm to their workers, some states have permitted a personal injury recovery.

While employers have the protection of workers' compensation exclusivity, in some cases, the manufacturer of the product that injured the workers can be sued for damages. However, the following must be shown:

- The product was the cause of the illness or injury to the workers.
- The manufacturer did not properly warn the workers that harm could occur from exposure to the product.

In recent years, the most widely known lawsuits have been brought by workers against the manufacturers of asbestos materials for asbestos-related diseases.

THE ROLE OF UNIONS AND OSHA

Both unions and OSHA help protect the legal rights of workers.

Unions

Unions are governed largely by the collective bargaining agreement. Many collective bargaining agreements provide detailed health and safety protections within the contract, health and safety committees, and frequently grievance procedures for health and safety concerns. If there are health and safety problems on the job site, workers should first contact the business agent of the union. If there is not a union, workers should become familiar with their legal rights under OSHA and other statutes, and be prepared to contact the appropriate agencies when a problem arises.

OSHA

OSHA protects workers from punishment or discrimination if any of their legal rights are violated. The director of the closest OSHA area office reviews a complaint and decides whether OSHA should investigate. If OSHA decides an investigation is necessary, an OSHA compliance officer or inspector conducts the investigation.

HEALTH AND SAFETY LIABILITY

The liability of employers, workers, and unions follows.

Employers

In most cases, employers are responsible for the health and safety of workers on the job site. Therefore, employers are principally responsible for injuries or illnesses to workers that resulted from actions they have taken or actions their workers have taken on the job site.

Workers

Workers are generally held immune from liability to third persons because they are considered to be acting on the employer's behalf in connection with activities on the job site. Also, workers generally do not have the economic resources that would make suits against them viable. However, immunity has its limits. Deliberate acts that lead to harm can be a civil and criminal liability against workers doing such acts.

Unions

Traditionally, unions have not been held liable for actions of employers and workers. Even though unions participate in health and safety committees through the collective bargaining process, employers have the final decision for on-the-job activities.

ASBESTOS ABATEMENT REGULATIONS

There are federal, state, and local regulations, as well as private contract specifications, that protect the health of workers on asbestos abatement projects. The following are major regulations that require detailed work practices on the job:

- OSHA Asbestos Standard for Construction 29 CFR 1926.1101.
- Asbestos control laws (some states).

In addition, the EPA enforces asbestos regulations that protect workers and the community by:

- Regulating the amounts of asbestos that can be released into outdoor air and water. (National Emission Standards for Hazardous Air Pollutants: Asbestos [*NESHAP*], U.S. EPA Title 40 CFR Part 61, Subpart M and the Clean Water Act.)

- Protecting public workers who remove asbestos. (Toxic Substances; Asbestos Abatement Projects. [Worker Protection Rule], U.S. EPA 40 CFR Part 763 Subpart G.)

- Specifying how to set up programs to deal with asbestos in schools and a model accreditation plan for states. (Toxic Substances; Title II; Asbestos-Containing Materials in Schools; Rule and Model Accreditation Plan; Rule 40 CFR Part 763 Part III April, 1987.)

Table 4-1 lists the major regulations and regulating agencies for asbestos abatement projects.

Table 4-1. These are the major regulations for asbestos abatement projects.

FEDERAL

U.S. Department of Labor, Occupational Safety and Health Administration (OSHA)

- OSHA Construction Standard for Asbestos 29 CFR 1926.1101 and all amendments. (There is also a general industry standard for asbestos, 29 CFR 1910.1001, but it does not apply to abatement jobs.)
- OSHA Standard for Respiratory Protection 29 CFR 1910.134.

U.S. Environmental Protection Agency (EPA)

- NESHAPS - National Emission Standards for Hazardous Air Pollutants; Asbestos 40 CFR Part 61, Subpart M.
- Toxic Substances, Title II Asbestos-Containing Materials in Schools; Rule and Model Accreditation Plan; Rule 40 CFR Part 763 Part III, April 1987.

U.S. Department of Transportation (DOT)

- Regulates transport of asbestos waste.

STATE

Department of Health

Department of Labor

LOCAL

Board of Health

- Have broad authority to regulate "what is hazardous in dwellings."

Fire Departments (in certain towns)

- Regulations concerning the types and uses of plastic sheeting used on jobs.

PRIVATE

Contracts and Job Specifications

- Generally written into the job specifications that all state and federal regulations must be followed.
- Contains additional requirements for the specific job.

OSHA Asbestos Standard for Construction 29 CFR 1926.1101

The OSHA Asbestos Standard for Construction 29 CFR 1926.1101 applies to all construction, demolition, alteration, maintenance, and repair work where building materials containing asbestos are present.

Standard 29 CFR 1926.1101 is important because it details the requirements for protecting employees if they are exposed to asbestos in the course of their work. It is divided into 17 paragraphs from (a) to (q). Table 4-2 lists the paragraphs and their titles.

A copy of the OSHA Asbestos Standard for Construction 29 CFR 1926.1101 appears in the Appendix section of this manual.

Table 4-2. Standard 29 CFR 1926.1101 has 17 paragraphs.

Paragraph	Titles
(a)	Scope and application
(b)	Definitions
(c)	Permissible exposure limits
(d)	Multi-employer work sites
(e)	Regulated areas
(f)	Exposure assessments and monitoring
(g)	Methods of compliance
(h)	Respiratory protection
(i)	Protective clothing
(j)	Hygiene facilities and practices for employees
(k)	Communication of hazards
(l)	Housekeeping
(m)	Medical surveillance
(n)	Recordkeeping
(o)	Competent person
(p)	Appendices
(q)	Dates

EPA National Emission Standards

The National Emission Standards for Hazardous Air Pollutants (*NESHAP*): Asbestos 40 CFR Part 61, Subpart M, Final Rule, November 20, 1990 applies to all owners and operators of demolition or renovation activities. The standard is divided into three major sections:

- Applicability
- Notification requirements
- Procedures for asbestos emission control

The standard specifies that no visible emissions can be released into the air during removal, demolition, or renovation of asbestos. (Visible emissions means any dust or cloud-containing particles of asbestos material that can be seen in the air without the aid of instruments.) This standard also requires that all material must be handled wet.

The requirements of this standard may vary depending on the size of the job and the condition of the regulated asbestos-containing material (*RACM*). For example, larger jobs must comply with EPA requirements when:

- The job requires more than 260 linear feet of asbestos pipe insulation.

- The job requires more than 160 square feet of asbestos-containing materials (*ACM*) on surfaces other than pipes.

- The total volume of material is 35 cubic feet or more, if the components cannot be measured.

Smaller jobs must simply comply with a portion of the EPA notification requirements.

The original Clean Air Act has been amended to reflect changes in the industry, and to enhance enforcement and promote compliance with the standard. It is the Clean Air Act that required the EPA to develop NESHAP regulations, shown in Table 4-3.

Table 4-3. Federal notification requirements for NESHAP and Worker Protection Rule.

NESHAP (EPA)

Type of Worker	Who and When to Notify	Type and Size of Project
Private	Owner or operator to notify EPA 10 days before start up	Demolition greater than or equal to 260 linear ft. or 160 sq. ft. or 35 cu. ft. of ACM
Private	Owner or operator to notify EPA 10 days before start up	Demolition less than or equal to 260 linear ft. or 160 sq. ft. or 35 cu. ft. of ACM
Private	Owner or operator to notify EPA as early as possible before start up, but not later than the next working day	Any demolition ordered by state or local government for structurally unsound buildings
Private	Owner or operator to notify EPA 10 working days before start up	Any renovation greater than or equal to 260 linear ft. or 160 sq. ft. of ACM
Public or Private	Owner or operator must obtain written permission from EPA	Any dry removal

WORKER PROTECTION RULE (EPA)

Type of Worker	Who and When to Notify	Type and Size of Project
Public	Employer to notify EPA as soon as possible, but **not later than** 48 hours after project begins	Any emergency
Public	Owner or operator to notify EPA 10 days before start up	Any asbestos abatement project; removal, enclosure, or encapsulation greater than or equal to 3 linear ft. or 3 sq. ft. (Any job less than this, meets the EPA definition of small scale, short duration.)

Note: Some states have regulations for notification that may differ or may be more stringent than the federal regulations.

4

The major changes in this regulation include:

- Owner/operator must notify EPA if the start date of a demolition or renovation changes from the original notification. (A notice must be given to EPA at least 10 days before renovation begins.)
- Owner/operator must provide additional information in the notifications.
- A person trained in the provisions of this rule must be on site when ACM is stripped, removed, or disturbed.
- When wetting is suspended because of freezing temperatures, the air temperature in the work area must be measured three times during the day, and the daily temperature records must be kept for at least two years.

This revision of NESHAP also clarifies EPA's position regarding the handling and treatment of nonfriable asbestos materials, such as resilient floor coverings (e.g., vinyl asbestos floor tiles) and roofing materials.

SECTION 4 - ASSIGNMENT SHEET

1. List at least ten legal rights workers have under the Occupational Safety and Health Act of 1970.

2. List the seven responsibilities workers have under the Occupational Safety and Health Act of 1970.

3. List seven steps workers should follow if they are punished for exercising any OSHA legal right.

ASBESTOS ABATEMENT WORKER REFRESHER

Section
5

Title
PERSONAL PROTECTIVE EQUIPMENT

TRAINEE OBJECTIVES

After completing Section 5, you will be able to:

1. Define the following terms:

   Maximum use concentration
   Protection factor
   Quantitative fit test
   Qualitative fit test
   Tested and certified

2. Define the following acronyms:
   APR
   HEPA
   IDLH
   NIOSH
   PAPR
   PPE
   SAR
   SCBA
   TC

3. List the PPE used by asbestos abatement workers.

4. List five types of respirators and their protection factors.

5. List the seven limitations of air purifying respirators.

6. List the three limitations of the supplied air respirator.

7. List the two limitations of SCBAs.

INTRODUCTION

Personal protective equipment (*PPE*) is any protective clothing or device used to prevent contact with, and exposure to, hazards in the workplace. Hazards may be chemical or nonchemical. Examples of PPE include:

- Respirators
- Gloves
- Protective suits such as Tyvek®
- Boots
- Hard hats
- Safety glasses

The PPE issue is made more complicated because no one type protects against all exposure situations. Choosing the correct type requires that the industrial hygienist have a detailed knowledge of the exposure(s) at hand.

PPE is critical to the safe performance of asbestos abatement work. Because asbestos abatement workers are most concerned with airborne hazards, this section focuses on respirators.

RESPIRATORY PROTECTION

A respirator is a piece of equipment that reduces exposures by limiting airborne contaminants from being inhaled. There are many different types of respirators, all useful in specific situations. Respirators are composed of a facepiece that seals out contaminants and a device that provides clean air. Two types of respirators are used for obtaining clean air:

1. Air purifying respirator – Uses filters to purify the air
2. Atmosphere supplying respirator – Provides a supply of clean air from a tank or hose

Respirators differ in how much protection they afford. A paper mask is less protective than a firefighter's respirator with an air tank. Industrial hygienists have developed a scoring system to rank different types of respirators. Each respirator is given a score based on the amount of protection it can provide. This score is known as a *protection factor* (*PF*).

Protection Factors

The key to understanding respirator protection is to realize that all respirators leak to a certain degree. The amount of leakage depends on how well the facepiece seals to the face. A leak in the facepiece means that contaminated air can enter the facepiece. These leaks compromise the protection given by the respirator. Breathing contaminated air can lead to adverse health effects depending on the type and amount of contaminant.

Respirators are tested for leakage by measuring the contaminant levels outside and inside the respirator. Using the ratio of these two measurements, a PF is calculated. A PF is based on the assumption that the respirator is working properly, is worn correctly, and fits the wearer. Figure 5-1 shows how to calculate a PF.

$$\text{PF} = \frac{\textbf{Concentration of airborne contaminant outside respirator}}{\textbf{Concentration inside the respirator}}$$

$$\text{PF} = \frac{500 \text{ f/cc} \text{ (concentration of asbestos outside the respirator)}}{50 \text{ f/cc} \text{ (concentration of asbestos inside the respirator)}}$$

PF = 10

f/cc = fibers per cubic centimeter

Figure 5-1. Calculating the protection factor

Respirator PFs range from 5 to 10,000. **The lower the PF, the lower the protection. The higher the PF, the higher the protection.**

The goal of a respirator is to reduce the amount of airborne contaminant inside the respirator to below the *permissible exposure limit* (*PEL*) set by the Occupational Safety and Health Administration (*OSHA*). The practical application of PF for the asbestos worker can be summed up as: How much of the outside contaminant level is reduced by the respirator? Examples follow:

- A respirator with a PF of 10 reduces a worker's exposure by 10 times or to 1/10 of the outside level. If the contaminant level outside the respirator is 100 *f/cc*, the level inside the respirator is 10 f/cc. If the

PEL for the contaminant is below 10 f/cc, the worker is overexposed. A PF of 10 means that the respirator can only be used in exposures up to 10 times over the PEL.

- A respirator with a PF of 10,000 reduces exposure by 10,000 times. The contaminant level inside the respirator may be 1/10,000 of the outside level.

Do not remove your respirator while in a contaminated area. The PF of the respirator will be reduced. Even a brief exposure can reduce the PF significantly. For example, the PF provided by an SCBA is 10,000, but:

- If you remove your respirator for 3 minutes in one hour (5% of the time), it is equal to reducing the PF from 10,000 to 100.

- If your remove your respirator for 6 minutes in one hour (10% of the time), the PF would be reduced to 10.

Remember: The lower the PF, the lower the protection. The higher the PF, the higher the protection.

Exposure Guides

When the the employer knows both the identity of a contaminant and its air concentration at the work site, specific exposure guides can be applied. Two commonly used exposure guides for concentration levels are:

1. Permissible exposure limit - set by OSHA

2. Threshold limit value - set by the American Conference of Governmental Industrial Hygienists (*ACGIH*).

A product's *material safety data sheet* (*MSDS*) must list chemical exposure limits. The limits may also appear on the product's container label.

Permissible Exposure Limits

Permissible exposure limits (*PEL*s) are legal guidelines for airborne concentrations of regulated substances. They set limits upon a worker's inhalation exposure or the amount of substance a worker can safely breathe. For example, the PEL for asbestos is 0.1 fiber per cubic centimeter (*f/cc*).

PELs are set by OSHA and are the only legally enforceable limits. This means that by law, employers must keep a worker's exposure below the PEL. PELs are meant to offer the minimum levels of protection—more protective limits are always allowed.

Threshold Limit Values

*Threshold limit value*s (*TLV*s) are set by the ACGIH. They are based on the best available information from industrial experience, experimental human studies, and animal studies. The basis on which the values are established may differ from chemical to chemical. TLVs are only advisory and are not legally enforceable. A revised list of TLVs is published each year, which makes them more current than PELs.

Representing Exposure Limits

There are several ways to represent exposure limits. However, for this section, only time weighted average will be covered.

Time weighted average (*TWA*) is the average concentration of a substance in an area over an 8-hour work shift of a 40-hour work week. To determine a TWA, exposure levels are collected over a work shift and then averaged for 8 hours.

Maximum Use Concentration

Maximum use concentration (*MUC*) is that level of contaminants which, if exceeded, will cause a worker to be exposed above the PEL because of leakage into the respirator. The MUC is the highest concentration of contaminants in which a respirator can be used safely. At no time should a respirator be used in an environment that exceeds the MUC.

The MUC is calculated by multiplying the PF by the PEL. Figure 5-2 shows how to calculate the MUC for asbestos.

MUC = PF x PEL

PF of half-face respirator	= 10
PEL for asbestos	= 0.1 f/cc

MUC =10 x 0.1 f/cc
= 1 f/cc

A half-face respirator cannot be used in atmospheres with an asbestos concentration greater than1 f/cc.

Figure 5-2. Calculating the MUC for asbestos.

AIR PURIFYING RESPIRATORS

Air purifying respirators (*APRs*) clean the air a worker breathes by removing or filtering contaminants. When a worker inhales, contaminated air is pulled into the respirator through a filter or cartridge attached to the facepiece. The filter or cartridge removes the contaminant from the air before it enters the facepiece through the inhalation valve. When the wearer exhales, the air flow is reversed. Air from the lungs flows out of the respirator through a separate valve called the exhalation valve.

Important: APRs must only be used when the oxygen level in the workplace is above 19.5 percent.

Negative Pressure Respirators

APRs are commonly called negative pressure respirators. They depend on lung power to pull the air through the filters. The suction created when a worker inhales pulls air into the respirator. This suction creates a momentary negative pressure inside the facepiece. The negative pressure brings contaminants into the facepiece through leaks and improper seals. During exhalation, air is blown out and a positive pressure is created in the facepiece.

Disposable Paper Masks and Quarter Masks

Disposable paper masks are familiar to many workers. Laboratory tests done with mannequins show these paper masks to have PFs of 5 to 10. The leakage for this type of mask is too severe for asbestos abatement work. The paper of a disposable mask only traps large-particle dusts. Gases, vapors, fumes, and fine dusts such as asbestos pass right through it. **Disposable paper masks are not used for asbestos abatement operations.**

Typically, the quarter mask is a rubber mask that fits from the top of the nose to the top of the chin. It uses cloth or cartridge filters and has a PF of 5. **Quarter masks are not used for asbestos abatement work.**

Half-Face APRs

Half-face APRs are the minimum type of respirator used for asbestos abatement work. The half-face APR is made of rubber or plastic. It fits from the top of the nose to under the chin (Figure 5-3). The fit given by this respirator rates a low PF of 10. An industrial hygienist must be confident in his or her knowledge of the level of asbestos exposure that will occur and how high the levels can potentially get to assign this type of respirator for use.

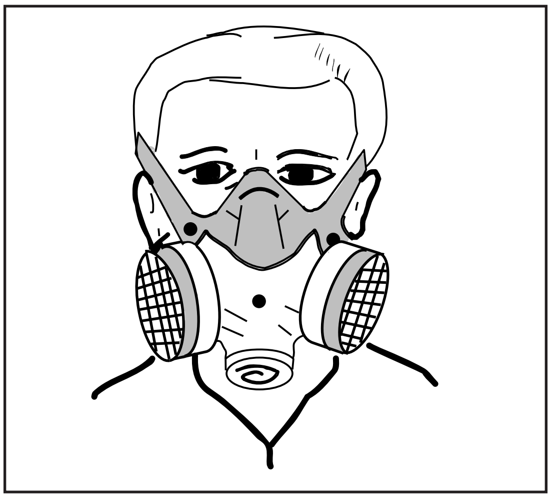


Figure 5-3. The half-face APR is the minimum type of respirator for asbestos abatement work.

Half-face APRs cannot be used with asbestos levels exceeding 1 f/cc. When the f/cc exceeds the MUC, workers are exposed above the PEL.

In the following example, workers can use a half-face respirator because the MUC does not exceed 1 f/cc.

PEL for asbestos	=	.1 f/cc
PF of half-Mask	=	10
MUC = (.1)(10)	=	1 f/cc

Reusable half-face APRS with high efficiency particulate air (HEPA) filters are approved for concentrations up to 1 f/cc (10 times the PEL).

Full-Face APRs

A full-face APR is made of rubber or plastic. It covers the whole face starting at the forehead, down over the temples and the eyes, and under the chin (Figure 5-4). Full-face APRs have a PF of 50, which means they are approved for asbestos concentrations up to 5 f/cc. This is higher than a half-face APR because it is easier to get a good seal across the forehead than across the nose. Also the respirator is held in place more securely because it has a harness instead of straps.

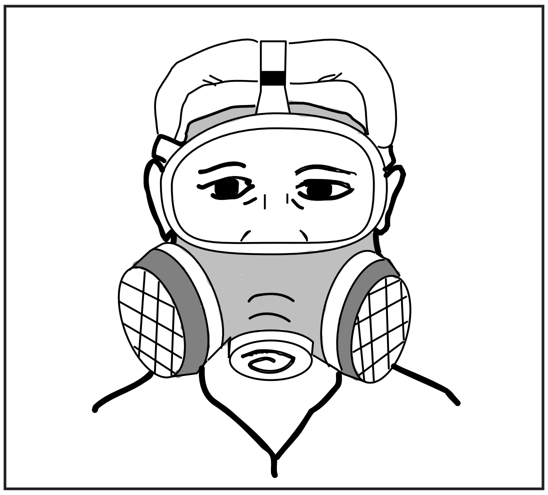


Figure 5-4. A full-face APR covers the whole face.

The full-face APR uses the same types of filters as the half-face APR, so it also carries the same limitations. It does protect the eyes, although it has a tendency to fog up. Some full-face APRs can use larger chin, chest, or back-mounted canister-type filters. Although full-face APRs protect more than half-face APRs, they still do not offer enough protection to be used in IDLH conditions.

Powered Air Purifying Respirator

The powered air purifying respirator (*PAPR*) uses the same type of facepiece and filters as the full-face APR (Figure 5-5). In addition, the PAPR has a small, lightweight battery-operated blower that pulls air through the filters and into the facepiece. This makes using a PAPR more comfortable because breathing is less work.

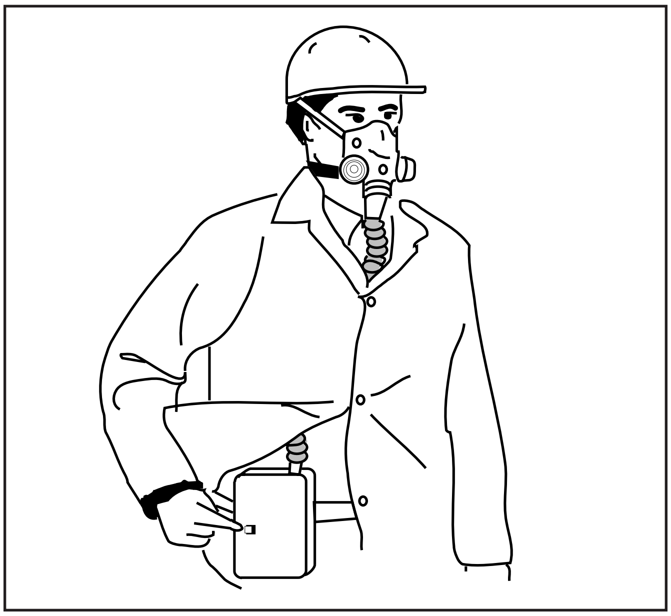


Figure 5-5. A powered air purifying respirator has a battery-operated blower.

OSHA assigns a PF of 100 to PAPRs with HEPA filters. This PF rating permits asbestos exposures up to 10 f/cc. The PAPR PF is higher than a full-face APR because the blower keeps a slight positive pressure inside the facepiece. For this reason leaks from an imperfect seal tend to be outward. The respirator is said to be pressurized or positively pressured. The result is less leakage and a higher PF.

Although the PAPR is an improvement over the full-face APR, it has two limitations:

- Weak batteries cause the fan motor to slow down. The batteries are designed to last a full shift and then require a full 8-hour charge.
- Under heavy work conditions, a worker can use more air then the PAPR provides. This creates a negative pressure in the mask. This condition is called *over breathing* a PAPR.

As a result of these limitations, NIOSH has assigned PAPRs a PF of 50.

Some PAPRs use loose-fitting hoods and helmets instead of facepieces. While these hoods are comfortable, they provide less protection. NIOSH recommends a PF of 25 for loose-fitting PAPRs.

Often, NIOSH recommends lower PFs for PAPRs than OSHA, showing there are some disagreements between agencies. However, OSHA is a regulatory agency, and so their PF ratings are legally enforceable. NIOSH PFs are not.

Limitations of APRs

All APRs, including PAPRs, have limitations in the following areas:

- Cartridge life
- Cartridge efficiency
- Oxygen limitations
- Unknown chemicals or chemical concentrations
- IDLH concentrations
- Humidity
- Usage
- Eye protection
- No eye protection

Cartridge Life

The cartridge or canister of an APR has a limited ability to remove chemical contaminants. When the saturation point is reached, chemicals begin to pass through the cartridge or canister. This condition is called *breakthrough*. Some chemicals have poor warning properties so a worker will not notice any chemical smell when breakthrough occurs. As a result, an APR cannot be used for chemicals with poor warning properties. Some filters have end-of-service-life indicators (*ESLI*), that change color when a filter is used up.

Cartridge Efficiency

There are many types of organic solvents, but only one type of organic solvent filter. Studies show that while this filter is very efficient for some solvents, it allows other solvents to pass through quickly.

For example, an organic vapor filter lasts:

- 143 minutes in an atmosphere with a concentration of 1,000 parts per million (*ppm*) of 1-nitropropane.

compared to:

- 5.6 minutes in an atmosphere with a concentration of 1,000 ppm of ethyl chloride.

Therefore, APRs are not used for solvents that have rapid breakthrough. However, not all solvents have been tested.

Oxygen Limitations

The APR can only be used when sufficient oxygen is present in the working atmosphere (Per OSHA, this is between 19.5 and 23.5 percent by volume). Normal breathing air contains about 21% oxygen.

Unknown Chemicals or Levels

The protection offered by an APR is limited, therefore, it cannot be used for unknown chemicals or concentration levels. The levels might exceed 10 times the PEL or different chemicals might go right through the filter to cause adverse health effects.

IDLH Concentrations

Under no circumstances should an APR be used in an IDLH atmosphere. For most chemicals this is not an issue because the MUC is lower than the IDLH level. But there are exceptions. For some chemicals, the IDLH is lower than the MUC, and the respirator can not be used if the level approaches the IDLH level.

Humidity

Some studies have shown that breakthrough occurs more quickly under conditions of high humidity.

Usage

The useful life of a cartridge or canister is limited once the filter is opened. Usually filters are discarded after each use (not exceed one shift). If breakthrough occurs and is noticed, then cartridges are changed at that time even if it is less than one shift.

Eye Protection

In addition to the cartridge-related limitations, the half-face APR has the additional limitation of having no eye protection. Therefore, goggles or face shields must be worn.

FILTERING DEVICES

Air purifying respirators are manufactured with two basic types of filtering devices:

1. Particulate filters
2. Vapor and gas removing cartridges and canisters

Particulate Filters

A particulate filter respirator uses a filter made of a fibrous material to capture contaminant particles before the air reaches the wearer's lungs. The particles are pulled through the filter as the worker inhales, where they become trapped by the fibers of the filter.

However particulate filters are not designed to be 100 percent efficient in removing particles from the air. The reason is that it would be too hard for a worker to breathe. The trapped particles plug the holes between the fibers. As more holes are plugged, breathing resistance increases. To prevent this situation, particulate filters are made to provide the highest possible filter efficiency while still keeping breathing resistance low.

HEPA Filter

High efficiency particulate air (HEPA) filters are capable of capturing 99.97 percent of particles 0.3 micrometers or larger in diameter from air pulled through the filter. HEPA filters are used for dusts, fumes, and mists having an exposure limit less than 0.05 milligrams per cubic meter of air (0.05 mg/m^3). Particulates with exposure limits this low are the most hazardous to workers' health, which explains why high efficiency filters are to be used.

42 CFR Part 84 for Particulate Filters

In 1972, the respirator certification regulations 30 CFR 11 were first promulgated and were commonly referred to as Part 11. Since that date, new research, tests, and technology have required that the certification regulations be revised. In July 1995, Part 11 was retitled 42 CFR 84 or Part 84.

NIOSH plans to revise the certification requirements for all respirator classes, although the process is expected to take many years. The revisions will take place in modules. The first module completed was the certification requirements for nonpowered, air-purifying, particulate-filtering respirators. These respirators now fall under Part 84. Therefore, all new nonpowered, air-purifying, particulate-filter respirators must be based on Part 84 performance testing procedures to receive NIOSH approval. All other respirators (PAPRs, SCBAs, etc.) are still under the Part 11 standard.

Filter Labels

Part 84 filter labels have two changes from Part 11 filter labels. These changes are shown below:

1. Sequence of approval numbers:

   Part 84 – TC-84A-XXXX
   Part 11 – TC-21C-XXX

2. Approving agencies:

   Part 84 – NIOSH and the Department of Health and Human Services (*DHHS*)

   Part 11 – NIOSH and Mine Safety and Health Administration (*MSHA*)

Labels are normally found on the respirator box, cartridge box, or backpack. Figures 5-6 shows the Part 84 label for nonpowered, air-purifying particulate filters. Figure 5-7 shows the Part 11 label for all other respirators.

PERMISSIBLE

Department of Health and Human Services
DHHS

Respirator for Dusts, Fumes, Mists, Asbestos, and Radionuclides

U.S. Department of Health and Human Services
Centers for Disease Control
NIOSH
National Institute for Occupational Safety and Health

DEPARTMENT OF HEALTH AND HUMAN SERVICES
NATIONAL INSTITUTE FOR OCCUPATIONAL
SAFETY AND HEALTH

APPROVAL NO. TC-84A-1234

ISSUED TO
WILSON SAFETY PRODUCTS
READING, PENNSYLVANIA, U.S.A.

LIMITATIONS

Approved for respiratory protection against dust, fumes, and mists having a Time Weighted Average (TWA) less than 0.05 milligrams per cubic meter, asbestos containing dusts and mists, and radionuclides. Not for use in atmospheres immediately dangerous to life or health. This respirator shall be selected, fitted, used, and maintained in accordance with Mine Safety and Health Administration, Occupational Safety and Health Administration, and other applicable regulations.

CAUTION

In making renewals or repairs, parts identical with those furnished by the manufacturer under the pertinent approval shall be maintained. Follow the manufacturers instructions for changing filters.

Figure 5-6. Part 84 label. NIOSH and DHHS are the approving agencies.

PERMISSIBLE

United States Department of Labor
MSHA
Mine Safety and Health Administration

Respirator for Dusts, Fumes, Mists, Asbestos, and Radionuclides

U.S. Department of Health and Human Services
Centers for Disease Control
NIOSH
National Institute for Occupational Safety and Health

DEPARTMENT OF HEALTH AND HUMAN SERVICES
NATIONAL INSTITUTE FOR OCCUPATIONAL
SAFETY AND HEALTH

APPROVAL NO. TC-21C-377

ISSUED TO
WILSON SAFETY PRODUCTS
READING, PENNSYLVANIA, U.S.A.

LIMITATIONS

Approved for respiratory protection against dust, fumes, and mists having a Time Weighted Average (TWA) less than 0.05 milligrams per cubic meter, asbestos containing dusts and mists, and radionuclides. Not for use in atmospheres immediately dangerous to life or health. This respirator shall be selected, fitted, used, and maintained in accordance with Mine Safety and Health Administration, Occupational Safety and Health Administration, and other applicable regulations.

CAUTION

In making renewals or repairs, parts identical with those furnished by the manufacturer under the pertinent approval shall be maintained. Follow the manufacturers instructions for changing filters.

Figure 5-7. Part 11 label. NIOSH and MSHA are the approving agencies.

Particulate Filter Classification

The Part 84 regulation created nine classes of particulate filters. The nine classes are made up of three filter series for resistance to filter efficiency degradation and three levels of filter efficiency.

The three filter series are labeled N, R, and P.

The **N series** has the following characteristics:

- Used for solid or water-based particulates.
- **Not** resistant to oil. Cannot be used in an atmosphere containing oil or for oil-based particulates.
- Can be used for more than one work shift if there are no problems with hygiene, damage, or breathing.

The **R series** has the following characteristics:

- Used for solid or liquid particles.
- Resistant to oil but not oil proof.
- Can be used for an extended time in an oil-free atmosphere.
- Has limited use time in an environment containing oil (one 8-hour shift or a combined total of 8 hours.)

The **P series** has the following characteristics:

- Used for solid or liquid particles, both oil-based and non-oil based.
- Is considered oil proof. Can be used as long as a worker has no breathing problems.

NIOSH update: NIOSH has issued an update to its selection guide. It was originally assumed the P-series filters would not degrade from oil exposure, and filters would only need to be changed when breathing resistance, hygiene concerns, or filter damaged occurred. However, a recent NIOSH study indicates the P-series of particulate filters may lose efficiency with long term exposure to oil.

NIOSH is recommending that whenever there is oil exposure to the P-filters, they should be replaced after each shift. There have been no changes to the selection logic for the N and R series filters.

An easy way to remember the filter series is:

- N is **N**ot resistant to oil
- R is **R**esistant to oil
- P is oil **P**roof

The three levels of filter efficiency are 95 percent, 99 percent, and 99.97 percent. These efficiency levels have the following designations:

- Filters with N95, R95, and P95 designations are certified as having a minimum efficiency of 95%.

- Filters with N99, R99, and P99 designations are certified as having a minimum efficiency of 99%.

- Filters with N100, R100, and P100 designations are certified as having a minimum efficiency of 99.97%. These filters replace the HEPA filters under the Part 11 certification standard. Unlike HEPA filters, both the N100 and R100 have the following limitations:

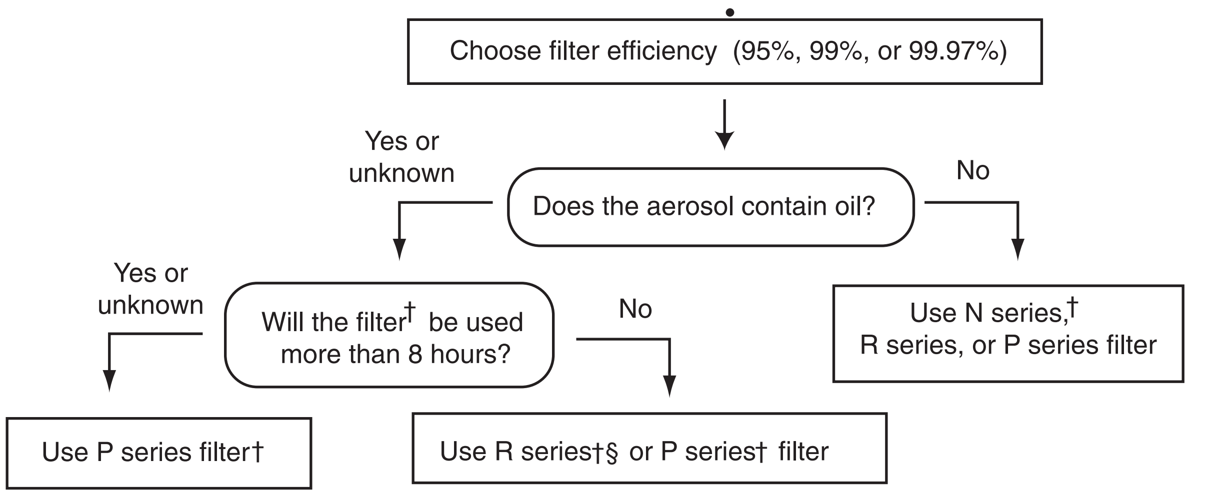
  – N100 - no oil exposure
  – R100 - oil exposure for one shift only

  The P100 filter is the only filter that will keep the familiar magenta color.

Table 5-1 summarizes the nine classes of particulate filters. Figure 5-8 illustrates the decision process for choosing the appropriate filter.

Table 5-1. Particulate filters have nine classes.

Filter Series	Filter Efficiency Series	Filter Classes	Service Time
N-Series	99.97%	N100	Non-specific
	99%	N99	Non-specific
	95%	N95	Non-specific
R-Series	99.97%	R100	One Shift
	99%	R99	One Shift
	95%	R95	One Shift
P-Series	99.97%	P100	Non-specific
	99%	P99	Non-specific
	95%	P95	Non-specific



• The higher the filter efficiency, the lower the filter leakage.

† Limited by considerations of hygiene, damage, and breathing resistance.

High (200 mg) filter loading in the certification test is intended to address the potential for filter efficiency degradation by solid or water-based (i.e., non-oil) aerosols in the workplace. Accordingly, there is no recommended service time in most workplace settings. However, in dirty workplaces (high aerosol concentrations), service time should only be extended beyond 8 hours of use (continuous or intermittent) by performing an evaluation in specific workplace settings that demonstrates (a) that extended use will not degrade the filter efficiency below the certified efficiency level, or (b) that the total mass loading of the filter is less than 200 mg (100 mg per filter for dual-filter respirators).

§ No specific service time limit when oil aerosols are not present. In the presence of oil aerosols, service time may be extended beyond 8 hours of use (continuous or intermittent) by demonstrating (a) that extended use will not degrade the filter efficiency below the certified efficiency level, or (b) that the total mass loading of the filter is less than 200 mg (100 mg per filter for dual-filter respirators).

Figure 5-8. Flow chart for selecting Part 84 particulate filters.

Vapor and Gas Removing Cartridges and Canisters

Vapor and gas removing cartridges and canisters are used with APRs to protect workers from exposures to air that is contaminated with toxic vapors and gases.

Contaminants are removed as inhaled air enters the cartridge or canister and passes through a granular material called a *sorbent*. The sorbent absorbs contaminants from the air and provides protection to the wearer from the toxic effects of the gas or vapor.

Materials used as sorbents include:

- Activated charcoal
- Silica gel
- Mixtures of specific chemicals that will capture the contaminant

Cartridges and Canisters

Sorbents for gases and vapors are packaged into either cartridges or canisters. The only difference between a cartridge and a canister is the amount of sorbent they contain. Cartridges are designed to be used singly or in pairs on quarter-, half-, and full-facepieces. The amount of sorbent contained in a cartridge is small, making their useful lifetime short in duration. This limitation restricts the use of cartridges to low concentrations of gases and vapors.

Canisters contain larger amounts of sorbent material than cartridges. They can be used in situations where the workplace air concentration of gases or vapors is high. Canisters are designed as chin, front, or back-mounted devices. When a canister is used with a facepiece, the respirator is called a gas mask.

Cartridge / Canister Use

Cartridges or canisters are designed for either one specific type of gas or vapor, or a combination of gases and vapors together. Some cartridges and canisters are manufactured to protect against gases, vapors, and particulates by combining particulate filters with sorbent materials.

Both canisters (gas masks) and chemical cartridges are available for the following specific gases and vapors:

- Acid gases (chlorine, hydrogen chloride, sulfur dioxide)
- Ammonia
- Formaldehyde
- Hydrogen fluoride
- Hydrogen sulfide
- Organic vapors
- Pesticides
- Vinyl chloride

Only chemical cartridges are available for these additional substances:

- Chlorine dioxide
- Mercury
- Paints, lacquers, and enamels

Likewise, only canisters (gas masks) are available for:

- Carbon monoxide
- Chlorine
- Ethylene oxide
- Hydrogen cyanide
- Hydrogen chloride
- Sulfur dioxide

A color coding scheme has been established to identify the contaminants that a gas and vapor canister or cartridge protects against. The color coding is assigned to either individual contaminants or combinations of contaminants as shown in Table 5-2.

Table 5-3 lists some of the chemicals that APRs **cannot** safely protected against.

Table 5-2. This table lists contaminants and their color codes.

Atmospheric Contaminant	Assigned Color
Acid gases	White
Organic vapors	Black
Ammonia gas	Green
Carbon monoxide gas	Blue
Acid gases and organic vapors	Yellow
Acid gases, ammonia, and organic vapors	Brown
Acid gases, ammonia, carbon monoxide, and organic vapor	Red
Other vapors and gases not listed above	Olive
Radioactive materials (except tritium and noble gases) (magenta)	Purple
Dusts, fumes, and mists (other than radioactive materials)	Orange

Table 5-3. Chemicals not suited for air purifying respirators

Acrolein	Methylene bisphenyl isocyanate
Aniline	Nickel carbonyl
Arsine	Nitro compounds
Bromide	Nitrobenzene
Carbon monoxide	Nitrogen oxides
Dimethylaniline	Nitroglycerin
Dimethyl sulfate	Nitromethane
Hydrogen cyanide	Ozone
Hydrogen fluoride	Phosgene
Hydrogen selenide	Phosphine
Hydrogen sulfide	Phosphorous trichloride
Methanol	Stibine
Methyl bromide	Sulfur chloride
Methyl chloride	Toluene diisocyanate

Breakthrough

Initially, a gas and vapor sorbent is 100 percent efficient in absorbing a contaminant. As the sorbent is used up, the efficiency decreases. When the sorbent is exhausted, the contaminant passes completely through the sorbent and into the facepiece, where it is inhaled by the wearer. This loss of capturing efficiency is called breakthrough. It is opposite to particulate filters, which become more efficient as particles collect on the filter.

Many chemicals have warning properties, such as odor, taste, or throat irritation. If you experience any of these warning signs, follow these steps:

1. Leave the work area immediately
2. Go to a location with fresh air
3. Notify the safety and health officer
4. Replace the cartridge or canister

Gas and vapor cartridges have short useful service times. It is recommended workers discard their cartridges or canisters at least daily, even if no odor, taste, or irritation is detected. However, if you notice that breakthrough has occurred, change the filters immediately, even if it has been less than one shift. Table 5-4 lists general MUCs for chemical cartridges that have hazardous breakthrough problems.

Table 5.4. Maximum use concentrations for chemical cartridges with hazardous breakthrough problems.

Type of Cartridge	Maximum Use Concentrations
Organic vapors	1,000 ppm
Acid gases	1,000 ppm
Sulfur dioxide	50 ppm
Chlorine	10 ppm
Hydrochloric acid	50 ppm
Ammonia	300 ppm
Methylamine	100 ppm

End-of-Service-Life Indicators

Some canisters are designed for use against substances with poor warning properties (no odor or taste). These canisters have end-of-service-life indicators (*ESLI*s) that show the canister is exhausted and needs to be replaced. For example, cartridges used for mercury have ESLIs because mercury has poor warning properties that are not readily noticed by a worker being exposed.

ATMOSPHERE SUPPLYING RESPIRATORS

Atmosphere supplying respirators supply clean breathable air to the wearer and do not depend on filters. The two types of atmosphere supplying respirators are:

1. Supplied air respirator (*SAR*)
2. Self-contained breathing apparatus (*SCBA*)

With an SAR, air is delivered to the wearer by a hose connected to a compressor. The compressor is equipped with a filtering system that purifies the air.

The air for an SCBA is contained either in a compressed air tank or cylinder. Regulators are used to reduce the pressure and control the flow of air into the facepiece. There are two types of regulators:

1. Demand flow
2. Pressure demand

Demand Flow vs. Pressure Demand Regulators

A demand flow regulator uses the suction force of inhalation to open the regulator valve and let air flow into the facepiece. In other words, when the worker “demands” the air, he or she gets it.

The advantage of the demand flow regulator is that the air supply is not wasted, so the time allowed by the tank is maximized. The disadvantage is that the regulator depends on negative air conditions during inhalation.

The PF for demand type atmosphere supplying respirators is only 50. A respirator with a demand flow regulator is **not** recommended for asbestos abatement work.

5

Pressure demand regulators are similar to demand flow regulators in that airflow into the facepiece occurs mainly during inhalation. However, there is also a constant flow of air into the mask that keeps it pressurized. Negative pressure conditions never exist, even during inhalation. Because positive pressure conditions exist at all times, leakage is minimized. A PF of 1,000 usually can be obtained with a pressure-demand regulator. NIOSH gives it a higher rating of 2000.

Supplied Air Respirators

Supplied air respirators (SARs) supply air to a facepiece through a length of hose (Figure 5-9). The hose is connected to either a compressed air cylinder or a compressor that is equipped with equipment to purify the air. With a pressure demand regulator, a PF of 1,000 can be typically obtained.

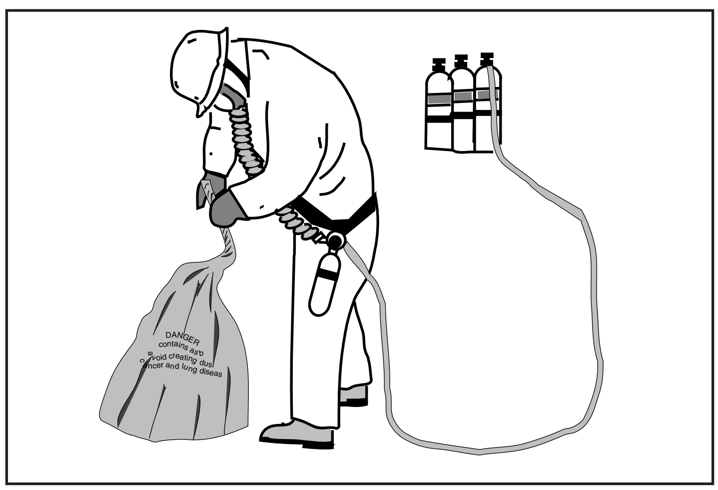


Figure 5-9. Air is delivered to a supplied air respirator through a hose.

The SAR is being used more and more for asbestos removal. However it does have the following limitations:

- The air line impairs worker movement. It cannot exceed 300 feet in length according to regulations.
- The air line can be damaged by rough or sharp surfaces that can puncture the line.
- The location of the system air compressor must be located away from potential chemical or contamination hazards.

Due to the limitations of SARs, they are often used with a small bottle of air called an escape SCBA. The escape SCBA has a 5 to 10 minute air supply. When the escape SCBA is provided, OSHA assigns the unit a PF of 10,000.

Type C Continuous Flow, Positive Pressure Respirators

The type C continuous flow, positive pressure respirator is approved for up to 10 f/cc for asbestos. Like the PAPR, the wearer can overbreath this type of respirator because air is delivered at one constant rate. For this reason, the type C continuous flow, positive pressure respirator has a PF of 100 and an MUC of 10 f/cc.

Type C Positive Pressure, Pressure Demand

A type C positive pressure, pressure demand respirator can be used for concentrations up to 100 f/cc. With a an escape SCBA, this respirator can be used in concentrations greater than 100 f/cc as well as unknown concentrations.

Self-Contained Breathing Apparatus

A *self-contained breathing apparatus* (*SCBA*) consists of a facepiece and regulator connected to a tank of compressed air that is worn by a worker (Figure 5-10). OSHA has assigned SCBAs a PF of 1,000 or greater. They may be used in asbestos concentrations greater than 100 f/cc.

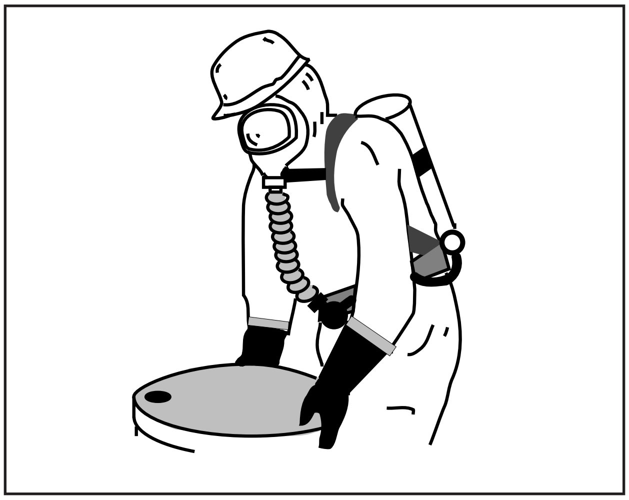


Figure 5-10. An SCBA receives air from a tank of compressed air.

The SCBA has two limitations: weight and a limited air supply. These limitations greatly affect the work schedule because the work day must be divided into many smaller segments. For this reason, the SCBA is not often used for asbestos abatement jobs.

5

Entry and Escape SCBAs

The typical pressure demand SCBA is an open circuit unit with a large cylinder. It provides enough air for 30 to 60 minutes and weighs about 25 or 30 pounds. This SCBA is called an entry SCBA and is good for any type of work.

Escape SCBAs are small cylinders capable of providing 5 to 10 minutes worth of breathable air. They do not provide enough air to do work and are only used for emergency evacuation. Some SARs have attached escape SCBAs, which provide additional protection. (PF is 10,000).

RESPIRATORY PROTECTION FOR ASBESTOS

The respirator chosen for use on an asbestos abatement job will depend upon the level of asbestos concentration. Table 5-5 shows the type of respirator required by OSHA for different airborne concentrations of asbestos.

Table 5-5. Respiratory protection based upon airborne concentrations of asbestos.

Airborne Concentration of Asbestos	Required Respirator
Not in excess of 1 f/cc (10 x PEL)	Half-mask, APR equipped with high-efficiency filters.
Not in excess of 5 f/cc (50 x PEL)	Full-facepiece APR equipped with high-efficiency filters.
Not in excess of 10 f/cc (100 x PEL)	Any powered APR equipped with high-efficiency filters.
	Any SAR operated in continuous flow mode.
Not in excess of 100 f/cc (1000 x PEL)	Full-facepiece SAR operated in pressure demand mode.
Greater than 100 f/cc (>1,000 x PEL) or unknown concentration	Full-facepiece SAR operated in pressure demand mode, equipped with an auxiliary positive pressure SCBA.

Note: (1) Respirators assigned for higher environmental concentrations may be used at lower concentrations.

(2) A high-efficiency filter means a filter that is at least 99.97 percent efficient against mono-dispersed particles of 0.3 micrometers in diameter.

RESPIRATOR SELECTION CRITERIA

Employers are responsible for selecting the appropriate respirators for their workers. Many employers use industrial hygienists for this purpose. The industrial hygienist evaluates the information gathered about the site and conditions and applies it to a selection process. The selection process is based upon NIOSH's Respirator Decision Logic and involves answering a series of questions to determine the specific respirator needed. The information gathered is critical in order to use the selection process logic. It must include the following:

- General use conditions/determination of contaminants
- Properties of the contaminants
- Odor threshold data
- Exposure limits
- IDLH concentrations
- Eye irritation potential
- Service life information

General Use Conditions/ Determination of Contaminants

General use conditions include the following:

- Descriptions of the job tasks to be performed
- Duration and frequency of the tasks to be performed
- Work location
- Physical demands of the work to be performed
- Respirator comfort

Determination of the contaminants includes the following:

- Identity of the substances present in the air
- The actual measured exposure level of the contaminant on the job

An industrial hygienist must determine the concentration of chemicals.

Properties of the Contaminants

Information is needed on the physical, chemical, and toxic properties of the contaminant. This information includes:

- Form in which the substance is found on the job site (dust, mist, fume, gas or vapor).
- Chemical properties, such as organic vapor, pesticide, metal, acid gas, etc.
- Toxic properties of the substance including potential adverse health effects (e.g., carcinogen, warning properties).

Odor Threshold Data

Information on odor threshold is essential to determine whether the contaminant has warning properties at or below the exposure limit that will allow APRs to be selected. If the odor threshold exceeds the exposure limits, the contaminant is considered to have poor warning properties. An APR would not be recommended for use unless it had an *end-of-service-life indicator* (*ESLI*). Data on odor thresholds would have to be obtained from industrial hygienists or other experts, such as NIOSH or OSHA.

Exposure Limits

Exposure limits include OSHA's PEL or NIOSH's recommended exposure limit *(REL*). This information is necessary if MUCs are to be calculated for the types or classes of respirators, using their assigned PFs.

IDLH Concentrations

Contaminant concentrations that are IDLH are life threatening and call for the use of the most protective respirators for the wearer. The IDLH concentration for a substance must be compared to the actual concentration measurement of the substance on the job.

Eye Irritation

Some contaminants have the potential to cause eye irritation. In these situations, a full facepiece, hood, or helmet should be selected to provide eye protection instead of a half mask.

Service Life Information

Collect any service life information that is available for cartridges and canisters used in APRs. Service life will help to determine the length of time that a cartridge/ canister could provide protection to the worker and can be used to establish cartridge replacement schedules.

RESPIRATORY PROTECTION PROGRAM

OSHA requires employers to have a written respiratory protection program whenever:

- Respirators are necessary to protect the health of workers
- The employer requires the use of respirators

The respiratory protection program must cover certain required work site-specific procedures for respirator use. Also, it must be updated when there are changes in workplace conditions that affect respirator use. The respiratory protection program includes the following requirements:

1. Procedures for selecting respirators for use in the workplace.

2. Medical evaluations of employees who are required to use respirators.

3. Fit testing procedures for tight-fitting respirators.

4. Procedures for proper use of respirators in routine situations and reasonably foreseeable emergencies.

5. Procedures and schedules for cleaning, storing, inspecting, repairing, discarding, and otherwise maintaining respirators.

6. Procedures to ensure adequate air quality, quantity, and flow of breathing air for atmosphere supplying respirators.

7. Employee training in the respiratory hazards to which they are potentially exposed during routine and emergency situations.

8. Employee training in the proper use of respirators, including:

   - *Donning* and *doffing*
   - Limitations
   - Maintenance

9. Procedures for regularly evaluating the effectiveness of the program.

Respirator Program Administration

The employer must designate a respirator program administrator (*RPA*) to oversee the respiratory protection program and to conduct the required evaluations of program effectiveness. To fulfill these duties, the RPA must have the training or experience that matches the complexity of the program.

As part of the administration of the program, the RPA is responsible for ensuring the following:

- Appropriate care is taken to properly select, use, and maintain the respirators.
- The nature of the air contaminant and its exposure concentration are considered in properly selecting a respirator.
- Workers are trained in the proper use and care of the respirators that are provided.
- Workers are medically fit to wear the respirator.

Voluntary Use of Respirators

Voluntary use of a respirator means that a worker chooses to wear a respirator when the employer does not require it. Even when respirator use is voluntary, the employer has several obligations. They are listed below:

1. Determine that the voluntary use of respirators will not create a hazard.
2. Provide workers who voluntarily use respirators with the information in 29 CFR 1910.134, Appendix D.
3. Establish and implement an abbreviated written respiratory protection program. This abbreviated program must include:
    - Provisions for initial medical screening of the voluntary respirator user.
    - The means and training so the user can properly clean, store, and maintain the respirator.

There is one exception regarding a written respiratory protection program for voluntary use. Employers are not required to include those workers whose voluntary use only includes *filtering facepieces* (dust masks).

Air Quality

OSHA regulation 29 CFR 1910.134 (i) addresses air quality, an important issue for atmosphere supplying respirators. Respirator air quality must, as a minimum, meet Grade D standards. Grade D air has the following limits:

- Oxygen content - 19.5-23.5% (Similar to outside air)
- Hydrocarbons - No greater than 5 mg/m^3 of air
- Carbon monoxide - No greater than 10 ppm
- Carbon dioxide - No greater than 1,000 ppm

Other issues addressed by section 1910.134 (i) include the following:

- Air cylinders must be tested and meet minimum standards to ensure that they can be safely pressurized.

- Air line couplings must be incompatible with outlets for other types of gases. This prevents against accidental injury from use of other gases by mistake.

- Compressors used for air line systems must have built in safety devices. These include:
  - Air purifying filters
  - Alarms for compressor failure
  - Alarms for overheating or high carbon monoxide levels
  - Reserve air systems to provide back up air in the case of compressor failure.

- Compressed oxygen shall not be used in supplied air regulators or in open circuit SCBAs that have previously used compressed air.

Note: Compressors used for pneumatic tools must not be used for air line systems. The air contains carbon monoxide and is unbreathable and dangerous.

Use of Respirators

Section 1910.134(g) of the OSHA Standards addresses usage questions. It includes the requirement that additional standby workers shall be present in areas where the atmosphere is toxic or oxygen-deficient and workers might be overcome if their respirators failed.

USER SEAL CHECKS

Respirators need to be selected and adjusted each time they are put on to ensure the best possible seal. There are two common procedures a worker must perform to check a facepiece seal:

- Positive pressure user seal check
- Negative pressure user seal check

Positive Pressure User Seal Check

To perform a positive pressure user seal check, follow these steps:

1. Cover the exhalation valve of the respirator.

2. Exhale gently for about 10 seconds. Do **not** exhale too hard or push the mask into the face or the check will be inaccurate.

If the respirator fits, a slight pressure should build up inside the facepiece. If air leaks out, the respirator does not fit properly, and the seal is inadequate. Figure 5-11 illustrates a positive pressure user seal check.

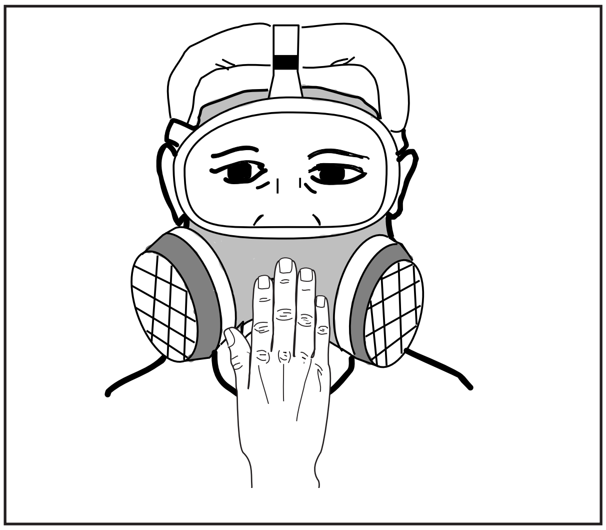


Figure 5-11. Positive pressure check user seal check

Negative Pressure User Seal Check

To perform a negative pressure user seal check, follow these steps:

1. Cover the filter openings with the palms of your hands.

2. Inhale gently and hold a breath for about 10 seconds. Do **not** push the respirator into the face too hard, or the check will be inaccurate.

If the respirator fits correctly, the facepiece should collapse slightly inward. If the respirator does not fit correctly, the facepiece will not collapse, and air will leak in. The negative pressure user seal check is shown in Figure 5-12.

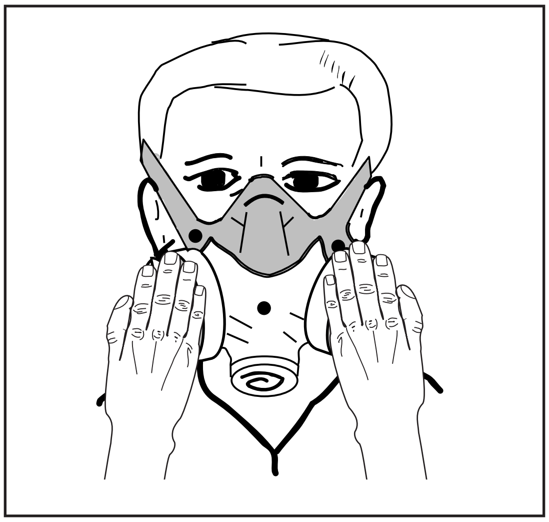


Figure 5-12. Negative pressure user seal check

QUALITATIVE FIT TESTING

A *qualitative fit test* (*QLFT*) involves introducing a harmless, odorous, or irritating substance into the breathing zone of the wearer. Four testing agents are used for a QLFT:

1. Banana oil (isoamyl acetate or isopentyl acetate)
2. Irritant smoke (stannic oxychloride or titanium tetrachloride)
3. Saccharin (sodium saccharin) solution
4. Bitrex (denatonium benzoate) solution

Qualitative fit testing addresses the following issues:

- Choosing the respirator needed.
- Determining comfort level. Comfort is important when respirators are used for long periods of time.
- Establishing a facepiece-to-face seal with a particular respirator.
- Identifying facial complications that affect the fit, such as dentures, facial surgery, or dental/oral surgery.

A QLFT relies upon a wearer's subjective response to the testing media. The wearer must inform the tester if he or she can smell or taste the substance. Because of the subjectivity of the QLFT, a respirator should never be assigned a PF higher than 10 when using this type of test.

Note: Before performing any test, make sure the correct respirator cartridges have been installed.

Fit Testing Protocols

A specific procedure or protocol has been provided by OSHA for the performance of all qualitative fit tests.

By following this protocol for each qualitative a fit test, the test results will be consistent from one test to another. A fit test chamber is used to ensure that the concentration of the testing agent is at the same level for the entire fit test. A sample fit test chamber is shown in Figure 5-13.

The American National Standards Institute (ANSI Z88.10 Respirator Fit Test Methods) has created protocols for fit testing respirators. OSHA has adopted ANSI's fit testing protocols as their own, and specifies them as the only allowable qualitative fit test protocols permissible for compliance.

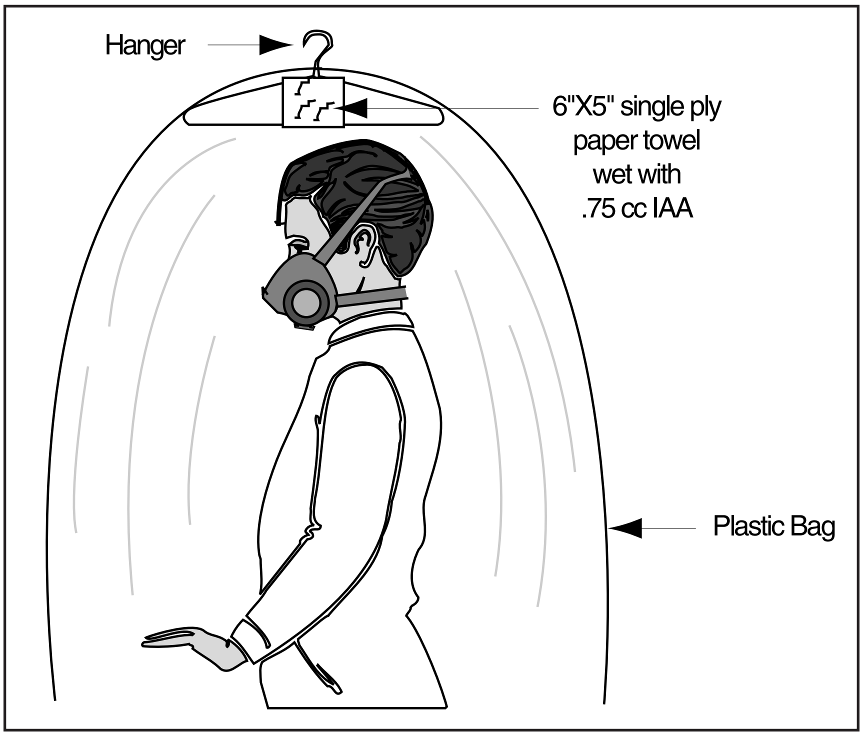


Figure 5-13. A fit test chamber ensures the concentration of the testing agent stays at the same level for the entire test.

When and Who Should Do the Fit Testing

A fit test must be given to any worker who is issued a respirator prior to entering a hazardous atmosphere. A fit test is generally good for 1 year. It must be retaken if a worker gains or loses 20 pounds, or has facial or oral surgery. Fit tests must be given by a trained and competent person who has a thorough understanding of respirator use and testing protocols.

Isoamyl Acetate Protocols

Isoamyl acetate (*IAA*) is also known as banana oil. Before using IAA as a fit testing agent, OSHA requires an odor threshold screening to be conducted. The screening determines if a worker can smell the IAA at low concentrations or 1 ppm. If the worker can detect the banana oil, he or she will be allowed to use this protocol.

Note: In some individuals, exposure to IAA may cause the following health effects:

- Olfactory fatigue - dulls the sense of smell
- Causes feelings of lightheadedness and drunkenness

This fit test requires that the respirator be fitted with an organic vapor cartridge or offer protection against organic vapors.

Irritant Smoke Test

Another fit testing agent is irritant smoke. It is very irritating to the eyes, nose, and throat, and usually causes the subject to cough. The worker being tested must keep his or her eyes closed during the fit test when wearing a half facepiece.

This test requires that the respirator be fitted with a HEPA or P100 series filter. They are color-coded white and purple or white and magenta.

No form of test enclosure (chamber or booth) or hood for the worker shall be used for this test. Adequate ventilation shall be provided in the fit test area to prevent exposure of the person conducting the fit test or the build-up of irritant smoke in the general atmosphere.

Saccharin Test

To use saccharin as a testing agent, the worker must participate in the saccharin taste threshold screening. This screening is performed without a respirator to determine if the worker can taste saccharin. (Some people cannot taste saccharin.)

The saccharin test uses a saccharin aerosol. If saccharin leaks into the facepiece, the worker will have a sweet taste on the lips and tongue. This test requires that the respirator be fitted with a particulate filter.

Bitrex Test

Bitrex is used as a taste aversion agent in household liquids. Like saccharin, workers must participate in a taste threshold screening before using bitrex as a testing agent. This screening is performed without wearing a respirator.

During the fit test, a small nebulizer is used to create a bitrex aerosol inside the test chamber. If bitrex leaks into the facepiece, the worker will have a bitter taste on the lips and tongue. The bitrex test uses the published saccharin test protocol because it is widely accepted. The respirator shall be equipped with a particulate filter.

QUANTITATIVE FIT TESTING

A *quantitative fit test* (QNFT) measures the actual amount of leakage into the respirator. It is the most sophisticated type of fit test. An aerosol generator is used to create an atmosphere of corn oil, salt, or other harmless aerosol inside a fit chamber or booth. Air monitoring instruments measure both the concentration inside the booth and the concentration inside the actual mask. (A measurement probe inserted into the mask samples the air inside the mask.)

OSHA has a procedure for quantitative fit testing. It is the same type of test that is done in research labs to develop the PFs described early in this section.

USING PERSONAL PROTECTIVE EQUIPMENT

PPE is an important defense against asbestos exposure when it is worn and used correctly. Training is critical to the safe and correct use of PPE for several reasons:

- Workers become familiar with PPE operation in a safe environment.
- Workers learn their limitations when wearing PPE.
- Workers become more skilled in doing a job while wearing PPE.
- Needless wear and tear on the PPE is reduced.
- Accidental exposures on the job are reduced.

OSHA requires employers to establish and implement procedures for the proper use of respirators. These procedures are listed below:

- Prohibiting conditions that may result in facepiece seal leakage.
- Preventing workers from removing respirators in hazardous environments.
- Taking actions to ensure continued effective respirator operation throughout the work shift.
- Establishing procedures for the use of respirators in IDLH atmospheres.

Personal Use Factors

Several items can affect the protection provided by respirators. The face-to-facepiece seal is the most important. OSHA requires that workers be trained to perform positive and negative pressure user seal checks as well as to receive fit tests on a regular basis.

Further, OSHA does not permit respirators to be worn under conditions that prevent a proper seal. Examples include the following:

- Facial hair
- Long hair
- Eyeglasses
- Gum and tobacco chewing
- The absence of one or both dentures
- Facial scars or deformities that hinder good fit

Facial Hair

A beard or long sideburns prevent a good seal between the face and the respirator. This includes a full beard, as well as a few days growth. A mustache is acceptable if it fits under the facepiece without affecting the seal.

Long Hair

Long hair may interfere with a good seal in some situations. The hair must be contained under the protective suit.

Eyeglasses

The temple bars that extend from the ear to the lens prevent the respirator from fitting up against the side of the head. Spectacle kits hold the lenses in place in the facepiece without temple bars. OSHA requires that this fitting be made available to workers with glasses at the employer's expense. Under no condition should a worker hesitate to request a spectacle kit.

Gum and Tobacco Chewing

Gum and tobacco chewing are prohibited when wearing a respirator. The chewing action puts a strain on the respirator seal. It can also lead to ingestion of contaminants.

Dentures, Scars, and Facial Deformities

If a respirator cannot conform to the shape of a face, a good face-to-facepiece seal may not be achievable. This may be cause by missing dentures, scars that cross under the seal, or a facial deformity.

Donning PPE

Donning is the act of putting on PPE. It is not difficult to put on the equipment, but a specific routine must be followed. The steps for donning PPE are listed below. Figure 5-14 shows rooms and areas listed in the steps.

Clean change room:

1. Remove all street clothes (e.g., undergarments and rings). Store them in a bin or locker.
2. Don the disposable undergarment.
3. Don the disposable coverall.
4. Don the disposable foot coverings (if separate foot coverings are used).
5. Tape the ankles to take up slack in the suit and to reduce the chance of tripping. (Tape the pants over foot coverings if they are two separate items.)
6. Inspect the respirator for possible problems. Don the respirator and perform user seal checks. Be sure the respirator is working properly.
7. Don the hood or head covering over the respirator head straps.
8. Walk through the air locks into the *equipment/dirty room.*

Equipment/dirty room:

9. Don the safety shoes/boots or deck shoes.
10. Don gloves. Cotton or leather gloves can be used during most types of asbestos abatement work.
11. Collect tools. Go through the air lock to the work area.

Work area:

Once inside the work area, workers must never leave without going through the decontamination process (doffing PPE), unless it is an extreme emergency. Common problems are workers “stepping in” to deliver messages or equipment or workers “stepping out” for a cigarette.

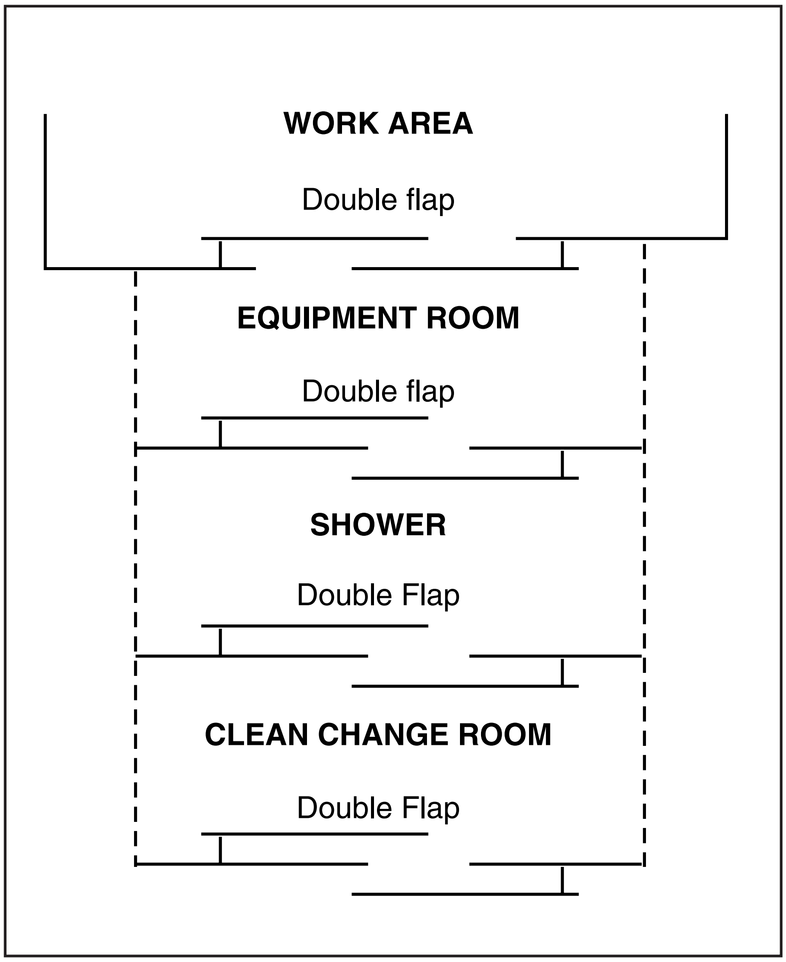


Figure 5-14. Workers don and doff PPE in the decontamination unit leading to the work area.

Doffing PPE

Doffing is the act of removing PPE. Again, it is important to follow the specific steps in each area when doffing PPE. Doffing is more complicated than donning because the PPE can be contaminated.

Work area or equipment/ dirty room:

1. Clean off the excess debris using a HEPA vacuum.

2. Remove all PPE except your respirator.

3. Place all disposable clothing in a plastic bag. Label the bag “asbestos-contaminated waste.”

4. Clean the reusable items as you remove them.

With the respirator still on:

5. Walk through the air lock to the *shower room*.

6. Begin showering. Start at your head and work downward. It is safe to remove your respirator after your head, shoulders and arms have been cleaned. Go to the *clean/change room*.

Clean change room:

7. Clean the respirator.

8. Wash face and hands before using the rest room, smoking, drinking, eating, or chewing gum or tobacco. Small amounts of asbestos on the face or hands can be a major route of exposure.

9. Put on street clothes.

INSPECTIONS

Inspections are an important part of a good PPE program. Checklists and written records are needed to verify and maintain the effectiveness and safety of the PPE. There are different types of inspections:

1. Inspection and testing of new equipment
2. Inspection of equipment at the time it is issued to workers
3. Inspection after use
4. Periodic inspection of stored equipment
5. Inspection when problems are reported

The responsibility to inspect PPE must be assigned to a specific qualified person. However, it is a good practice for workers to know how to do a basic equipment inspection.

SECTION 5 - ASSIGNMENT SHEET

1. Define the following terms:

   Maximum use concentration ____________________

   Protection factor ____________________

   Quantitative fit test ____________________

   Qualitative fit test ____________________

   Tested and certified ____________________

2. Define the following acronyms:

   APR ____________________

   HEPA ____________________

   IDLH ____________________

   NIOSH ____________________

   PAPR ____________________

   PPE ____________________

   SAR ____________________

   SCBA ____________________

   TC ____________________

3. List the PPE used by asbestos abatement workers.

   ____

   ____

   ____

   ____

4. List five types of respirators and their protection factors.

5. List the seven limitations of air purifying respirators.

6. List the four limitations of the full-face atmosphere supplying respirator.

7. List the two limitations of SCBAs.

SECTION 5 - STANDARD OPERATING PROCEDURE 1

A. Inspect the half-face APR. Check all parts for signs of dirt, wear, tears, and integrity. Ensure that all parts can and will work properly by using the following steps:

1. Check general appearance (no deformities).
2. Check harness and strap assemblies.
3. Check nose cup.
4. Check facepiece seal area.
5. Check inhalation valves.
6. Check exhalation valve, valve seats, and cover.
7. Check cartridge or filter holder and gaskets.
8. Check cartridges or filters.

B. Don a half-face APR using the following steps:

1. Inspect the respirator (8 steps from A., Standard Operating Procedure 1).
2. Loosen the harness assembly completely.
3. Hang the facepiece around your neck using the neck strap (if available).
4. Raise the facepiece upward and open, exposing your chin and nose cup.
5. Place your chin in the chin cup and pull the harness over the top of your head. (Make sure there is no hair or other obstructions between your face and facepiece.)
6. Tighten the bottom two harness straps (not too tight).
7. Tighten the top strap slightly.
8. Adjust the mask if needed. The mask should be centered on your face.

C. Perform a negative pressure check with the half-face APR.

1. Inspect the respirator (8 steps from A., Standard Operating Procedure 1).

2. Don the respirator (8 steps from B., Standard Operating Procedure 1).

3. Cover the filter/cartridge inlet openings. (Use the palms of your hands, duct tape, plastic wrap, or surgeon's gloves.) Cover the filter/cartridge inlet openings with the palms of your hands, duct tape, plastic wrap, or surgeon's gloves.

4. Inhale, so the facepiece collapses inward, and hold for ten seconds.

5. If the facepiece stays collapsed, continue with Step 7.

6. If there is leakage, readjust the facepiece and try again. If there is still leakage, reinspect the respirator and try again. If you still can't get a seal, try a different size and/or respirator.

7. Remove the coverings from the filter or cartridge inlets.

D. Perform a positive pressure check with the half-face APR.

1. Inspect the respirator (8 steps from A., Standard Operating Procedure 1).

2. Don the respirator (8 steps from B., Standard Operating Procedure 1).

3. Cover the exhalation outlet. (Use the palms of your hands, duct tape, plastic wrap, or surgeon's gloves.)

4. Exhale, so the facepiece is enlarged slightly, and hold for ten seconds.

5. If the facepiece stays enlarged, continue with Step 7.

6. If there is leakage, readjust the facepiece and try again. If there is still leakage, reinspect the respirator and try again. If you still can't get a seal, try a different size and/or respirator.

7. Remove the coverings from the exhalation outlet.

E. Clean, sanitize, and maintain a half-face and/or full-face APR using the following steps:

1. Remove and properly discard filters and/or cartridges.
2. Immerse the respirator in a warm (about 120°) solution of germicidal or disinfecting detergent.
3. Scrub the respirator body and parts gently with a cloth or soft brush.
4. Rinse in clean, warm water (about 120° F).
5. Shake gently to remove excess water. It may be necessary to tip the respirator in several directions.
6. Wipe the respirator with a soft, clean cloth (if available) or allow to air dry away from direct heat or sunlight.
7. Inspect the respirator (8 steps from A., Standard Operating Procedure 1).
8. Replace all damaged or missing parts according to the manufacturer's instructions.
9. Loosen harness straps.
10. Place respirator in a clean bag, box, or storage area in a cool, dry place. Do not place any weight on the respirator.

SECTION 5 - STANDARD OPERATING PROCEDURE 2

Complete an Isoamyl Acetate (IAA) Qualitative Fit Test using the following steps:

1. Read the following instructions. These instructions will be typed on a card and placed on the table in front of the two test jars (1 and 2).

   "The purpose of this test is to determine if you can smell banana oil at a low concentration. The two jars in front of you contain water. One of these jars also contains a small amount of banana oil. Be sure the covers are on tight, then shake each jar for two seconds. Unscrew the lid of each jar, one at a time, and sniff at the mouth of the jar. Indicate to the test conductor which jar contains banana oil."

2. Make sure each of the covers are on tight, and shake each jar for two seconds.

3. Unscrew the lid of each jar one at a time, and sniff at the mouth of the jar.

4. Indicate to the person conducting the test which jar contains the banana oil.

5. If you are unable to correctly identify the jar containing the odor test solution, the IAA QLFT may not be used.

6. If you correctly identify the jar containing the odor test solution, proceed to Step 7.

7. Select the most comfortable respirator from the various sizes and manufacturers by holding each facepiece up to your face, and eliminating the ones that don't fit comfortably. Normally, selection will begin with a half-mask. If a half-mask respirator can't be found, look for a full-facepiece respirator. (A small percentage of users will not be able to wear any half-mask). Each respirator represents a different size and shape. If the respirator fits properly, it will provide adequate protection. The selection process shall be conducted in a room separate from the fit test chamber to prevent odor fatigue. A mirror shall be available to assist you in the evaluation of the fit and positioning of the respirator.

8. Inspect the chosen respirator, make sure that it is equipped with an organic vapor cartridge. Don and wear the most comfortable mask for at least five minutes to assess comfort. Assess comfort by discussing and reviewing the following points with your instructor(s).

   - Chin properly placed
   - Positioning of mask on nose
   - Strap tension
   - Fit across nose bridge
   - Room for safety glasses
   - Distance from nose to chin
   - Room to talk
   - Tendency to slip
   - Cheeks filled out
   - Self-observation in mirror
   - Adequate time for assessment

9. If you are not familiar with using a particular respirator, your instructor(s) will help you inspect and don the mask several times. Adjust the straps each time, so that you set the proper tension on the straps.

10. After selecting, donning, and properly adjusting a respirator, "seat" the mask by rapidly moving the head side to side and up and down, taking a few deep breaths.

11. Conduct the conventional negative and positive pressure fit checks (e.g. see ANSI Z88.2-1980 - see Standard Operating Procedure 1 - A. and B.)

12. Wear the respirator for at least 10 minutes before starting the fit test.

13. Enter the fit test room, get the 6-inch by 5-inch piece of paper towel or other porous absorbent single ply material. Fold the paper towel in half, and wet it with three-quarters to one cc of pure IAA from the instructor. Hang the wet towel on the hook at the top of the chamber.

14. Allow two minutes for the IAA test concentration to be reached before starting the fit-testing exercises. Read the test exercises that are taped to the inside of the test chamber. Use this time to ask the instructor(s) any questions or to have them demonstrate exercises.

15. Perform the following test exercises for at least one minute each.

    a. Breath normally.

    b. Breathe deeply. Be certain that breaths are **deep** and **regular.**

    c. Turn head from side to side. Be sure movement is complete. Do not bump the respirator on your shoulders. Inhale when the head is at either side.

d. Nod head up and down. Be certain motions are complete and made about every second. Do not bump the respirator on your chest. Inhale when your head is in the full up position.

e. Talk aloud and slowly for several minutes. Read the following Rainbow Passage. Reading this passage results in a wide range of facial movements; and thus, useful to satisfy this requirement.

"When the sunlight strikes raindrops in the air, they act like a prism and form a rainbow. The rainbow is a division of white light into many beautiful colors. These take the shape of a long round arch, with its path high above, and its two ends apparently beyond the horizon. There is, according to legend, a boiling pot of gold at one end. People look, but no one ever finds it. When a man looks for something beyond reach, his friends say he is looking for the pot of gold at the end of the rainbow."

f. Breath normally.

16. If at any time during the test, you detect the banana-like odor of IAA, quickly exit the test chamber and leave the test area to avoid olfactory fatigue.

17. If you have detected the odor, return to the selection room and remove the respirator. Repeat the odor sensitivity test and select another respirator. If you can't be fitted with the selection of half-mask respirators, include full facepiece models in your selection process. Return to the test by starting at Step 8 above.

18. If you complete the test without detecting the banana-like odor, break the face seal and take a breath before exiting the chamber. This demonstrates the efficiency of the respirator.

19. Remove the saturated towel from the hook, leave the test chamber, and return the towel to the instructor(s).

20. If you successfully passed this fit test, you may be assigned the use of the tested respirator in atmospheres with up to 10 times the PEL. In other words, this IAA protocol may be used to assign a protection factor no higher than 10.

21. After passing the fit test, assess the comfort of the respirator using the steps outlined above. If the respirator becomes uncomfortable, try another respirator model and conduct a fit test.

SECTION 5 - STANDARD OPERATING PROCEDURE 3

A. Complete an irritant smoke or Isoamyl Acetate Qualitative Fit Test using the following steps:

1. Smell a weak concentration of the test agent.
2. Inspect the respirator (8 steps from A., Standard Operating Procedure 1).
3. Don the respirator (8 steps from B., Standard Operating Procedure 1).
4. Perform a negative pressure check (5 steps from C., Standard Operating Procedure 1).
5. Perform a positive pressure check (5 steps from D., Standard Operating Procedure 1).
6. Wear the respirator for at least 5 minutes.
7. Step into the test chamber or bag.
8. Close your eyes.
9. Breathe normally.
10. Breathe deeply. (Breaths must be deep and regular.)
11. Turn your head from side to side.
12. Nod your head up and down.
13. Read the Rainbow Passage.
14. Jog in place.
15. Breathe normally.
16. If the test agent is detected, get out of the test chamber and readjust the mask. Repeat Steps 4 through 15.
17. If the test agent is still detected, select another size and/or type respirator and repeat Steps 2 through 15.
18. Clean, sanitize, and maintain the respirator (10 steps from E., Standard Operating Procedure 1).

SECTION 5 - STANDARD OPERATING PROCEDURE 4

A. Inspect a full-face APR using the following steps. Check for signs of wear, dirt, and integrity. Check to ensure that all parts work properly.

1. Overall general appearance (no deformities).
2. Harness assembly and connections.
3. Lens and lens gasket.
4. Face to facepiece seal area.
5. Inner nose cup.
6. Inhalation valves and their seating surfaces.
7. Exhalation valves and their seating surfaces.
8. Filter or cartridge assembly.
9. Filter or cartridge.
10. Install proper filter or cartridge.

B. Don a full-face APR using the following steps:

1. Inspect the respirator (10 steps from A., Standard Operating Procedure 3).
2. Loosen the harness assembly completely.
3. Hang the facepiece around your neck using the neck strap (if available).
4. Raise the facepiece upward and open to expose the your chin and nose cup.
5. Place your chin in the chin cup and pull the harness over the top of your head. Make sure there is no hair or other obstructions between your face and facepiece.
6. Tighten the bottom harness straps (not too tight).

7. Tighten the middle two harness straps.

8. Tighten the top strap slightly.

9. Adjust the mask if needed. (The mask should be centered on your face.)

C. Perform a negative pressure check with a full-face APR.

1. Inspect the respirator (10 steps from A., Standard Operating Procedure 3).

2. Don the respirator (9 steps from B., Standard Operating Procedure 3).

3. Cover the filter or cartridge inlet openings. (Use the palms of your hands, duct tape, plastic wrap, or surgeon's gloves.)

4. Inhale, so that the facepiece collapses and hold for ten seconds.

5. If the facepiece stays collapsed, go to Step 7.

6. If there is leakage, readjust the facepiece and try again. If there is still leakage, reinspect the respirator and try again. If you still can't get a seal, try a different size and/or respirator.

7. Remove the coverings from the filter or cartridge inlets.

D. Perform a positive pressure check with the full-face APR.

1. Inspect the respirator (10 steps from A., Standard Operating Procedure 3).

2. Don the respirator (9 steps from B., Standard Operating Procedure 3).

3. Cover the exhalation outlet. (Use the palms of your hands, duct tape, plastic wrap, or surgeon's gloves.)

4. Exhale, so that the facepiece is enlarged slightly and hold for ten seconds.

5. If the facepiece stays enlarged go to Step 7.

6. If there is leakage, readjust the facepiece and try again. If there is still leakage, reinspect the respirator and try again. If you still can't get a seal, try a different size and/or respirator.

7. Remove the coverings from the exhalation outlet.

SECTION 5 - STANDARD OPERATING PROCEDURE 5

A. Don and doff the following personal protective equipment:

- Respiratory protection (half-face and/or full-face APR).
- Disposable coveralls, disposable foot covering, disposable head covering.
- Disposable underwear (nylon or cotton swimsuit may sometimes be permitted).
- Work shoes or other appropriate foot coverings.
- Hard hat (as required).
- Gloves (cotton is practical, but rubber may be required).
- Eye and hearing protection. (Eye protection is not needed, if full-facepiece respirators are used.)

Donning:

1. Remove all street clothes, including undergarments. Store street clothes in a clean, convenient location. (Bins or lockers work well.)
2. Put on disposable undergarments.
3. Put on disposable coveralls.
4. Put on disposable foot coverings (if separate disposable foot coverings are used).
5. Tape ankles to take up the slack in the suits and to reduce the chance of tripping. (Tape pants over foot coverings, if separate.)
6. Put on the respiratory equipment. (Respirator equipment should have been inspected and fit checked.)
7. Put on the hood and head covering over the respirator head straps.
8. Pass through air lock and shower into the work area.

9. Put on safety shoes/boots as required.

10. Put on gloves. (Cotton or leather gloves can be used during most types of abatement work. However, when working with caustic pastes, use rubber gloves or gloves that the chemical can't pass through. Gloves used with caustic paste or chemical strippers should also be long enough to protect the lower part of the arm, as well as the hand.)

11. Put on the hard hat and/or safety glasses (if a half-face respirator is used) or any other protective equipment.

Doffing:

1. Clean off the gross debris using a HEPA vacuum inside the work area.

2. Remove all protective garments and equipment (except respirators) in the "dirty" or work area. Place all disposable clothing in plastic bags, and label as "asbestos-contaminated waste."

3. Clean reusable protective equipment, such as boots/shoes, safety glasses, hard hats, etc., as they are removed.

4. Proceed through the air lock to the clean area with respirator still on. Remove and clean respiratory protection. Change the filters on a regular basis and discard filters as "asbestos-contaminated waste." Showers are recommended as part of good work practices after all the protective equipment is removed. In lieu of a shower, wash your face and hands prior to going to the bathroom, smoking, drinking, eating, or chewing gum or tobacco, etc. Upon leaving the work area, you should take a shower as soon as possible to help remove any asbestos contamination. Small amounts of asbestos on the hands or in the hair can result in a major route of exposure through ingestion.

5. Get dress in your street clothes. Disinfect, clean, and inspect the respirator. If cartridges are discarded, new cartridges should be placed in the respirator. Store respirator in a clean and dry environment.

APPENDIX 5-1
RESPIRATOR PROFILES

Half-Facepiece

Other common names: cartridge mask, type A mask, negative pressure mask, APR
Assigned protection factor: 10
Limitations: Can only be used at low exposure levels where contaminants are known and adequate filters are available. Cannot be worn in an oxygen-deficient atmosphere. Contaminant should have adequate warning properties.

Full-Facepiece

Other common names: cartridge mask, canister mask, negative pressure mask, APR
Assigned protection factor: 50
Limitations: Limited protection. Can only be used when exposure levels are fairly low, (less than 50 x PEL) and contaminants are known. Limited selection of filters. Cannot be worn in an oxygen-deficient atmosphere.

Powered Air Purifying

Other common names: PAPR
Assigned protection factor:
100 . . . . OSHA
50 . . . . NIOSH
25 . . . . NIOSH (for loose-fitting hood models)
Limitations: Protection depends on charged battery. Use restricted by considerations as other full-face masks. Can't be worn in an oxygen-deficient atmosphere.

Supplied Air Respirator

Other common names: hose masks, SAR masks, type C respirators
Assigned protection factor:
1,000 - OSHA full-face positive pressure, pressure demand (pppd)
1,000 + - NIOSH full-face pppd equipped with auxiliary escape SCBA operated in pppd mode.
Limitations: Problems with hose (prone to tangling and damage).

Self-Contained Breathing Apparatus

Other common names: SCBA
Assigned protection factor: 50 for demand units
10,000 for pressure demand units.
Limitations: Very heavy. Air supply is limited to 30 or 60 minutes in 2200 psi or 4500 psi cylinders.

APPENDIX 5-2

RESPIRATOR DECISION LOGIC SEQUENCE

After criteria information is gathered and evaluated, the industrial hygienist follows a sequence of questions to identify the NIOSH recommended class of respirators for the airborne contaminants. The questions listed below are summarized from the Respirator Decision Logic document.

1. *Is the respirator to be used for firefighting?*
   a. If yes, use a full facepiece SCBA operated in a pressure demand mode.
   b. If no, go to step 2.
2. *Will the respirator be used in an oxygen deficient atmosphere?*
   a. If yes, any type SCBA or atmosphere supplying respirator with auxiliary SCBA can be used.
   b. If no, go to step 3.
3. *Will the respirator be used in emergency situations?*
   a. If yes, use a full facepiece SCBA operated in a pressure demand mode or a full facepiece atmosphere supplying respirator operated in pressure demand mode in combination with an auxiliary SCBA operated in pressure demand mode.
   b. If no, go to step 4.
4. *Is the contaminant a carcinogen?*
   a. If yes, use a full facepiece SCBA operated in pressure demand mode, or a full facepiece atmosphere supplying respirator operated in pressure demand mode in combination with an auxiliary SCBA operated in pressure demand mode.
   b. If no, go to step 5.
5. *Is the contaminant exposure level less than the OSHA PEL or NIOSH REL?*
   a. If yes, a respirator is not required except for escape. Go to step 7.
   b. If no, go to step 6.
6. *Is contaminant exposure level less than IDLH concentratio*n?
   a. If yes, go to step 7.
   b. If no, conditions are IDLH. Use a full facepiece SCBA operated in pressure demand mode or a full facepiece atmosphere supplying respirator operated in pressure

demand mode in combination with an auxiliary SCBA operated in pressure demand mode.

7. *Is the contaminant an eye irritant?*

   a. If yes, respirators with full facepieces, helmet, or hood are recommended. Go to step 8.

   b. If no, half mask respirators may be used, depending on exposure concentration. Go to step 8.

8. *Determine the minimum PF that is required.*

   Divide the measured exposure concentration of the contaminant by its OSHA or NIOSH exposure limit. For escape respirators, determine the potential for a hazardous condition to occur caused by an accident or equipment failure. Go to step 9.

9. *If the contaminant is a particulate, go to step 10.*
   If the contaminant is a gas or vapor, go to step 11.
   If the contaminant is a combination, go to step 12.

10. *Particulate Respirators*

    10.1 Is the particulate respirator to be used only for escape purposes?

    a. If yes, use the table of NIOSH recommendations for escape respirators.

    b. If no, the respirator will be used for normal work activities. Go to step 10.2.

    10.2 Determine the type of filter that should be used for the particulate contaminant. Go to step 10.3.

    10.3 Select a particulate respirator with a PF equal to or greater than the minimum PF calculated in step 8.

11. *Gas/Vapor Respirators*

    11.1 Is the gas/vapor respirator to be used only for escape purposes?

    a. If yes, use the table of NIOSH recommendations for escape respirators.

    b. If no, the respirator will be used for normal work activities. Go to step 11.2.

    11.2 Are the warning properties for the gas/vapor contaminant adequate at or below the exposure limit (PEL or REL)?

    a. If yes, go to step 11.3.

b. If no, an APR equipped with an ESLI, a atmosphere supplying respirator, or an SCBA is recommended. Go to step 11.4.

11.3 An APR chemical cartridge/canister respirator is recommended. Go to step 11.4.

11.4 Select a gas/vapor respirator with a PF equal to or greater than the minimum PF calculated in step 8.

12. Combination Particulate and Gas/Vapor Respirators

12.1 Is the combination respirator to be used only for escape purposes?

a. If yes, use the table of NIOSH recommendations for escape respirators.

b. If no, the respirator will be used for normal work activities. Go to step 12.2.

12.2 Does the gas/vapor contaminant have adequate warning properties at or below the exposure limit (PEL or REL)?

a. If yes, go to step 12.3

b. If no, an APR equipped with an ESLI, an atmosphere supplying respirator, or an SCBA is recommended. Go to step 12.4.

12.3 Use an APR with chemical cartridge/canister that has a particulate pre-filter. Go to step 12.4.

12.4 Select a combination gas/vapor and particulate respirator with a PF equal to or greater than the minimum PF calculated in step 8.

The respirator decision flow chart shown in Figure 5-15 helps the selector organize the information and keep track of the flow of questions in the sequence.

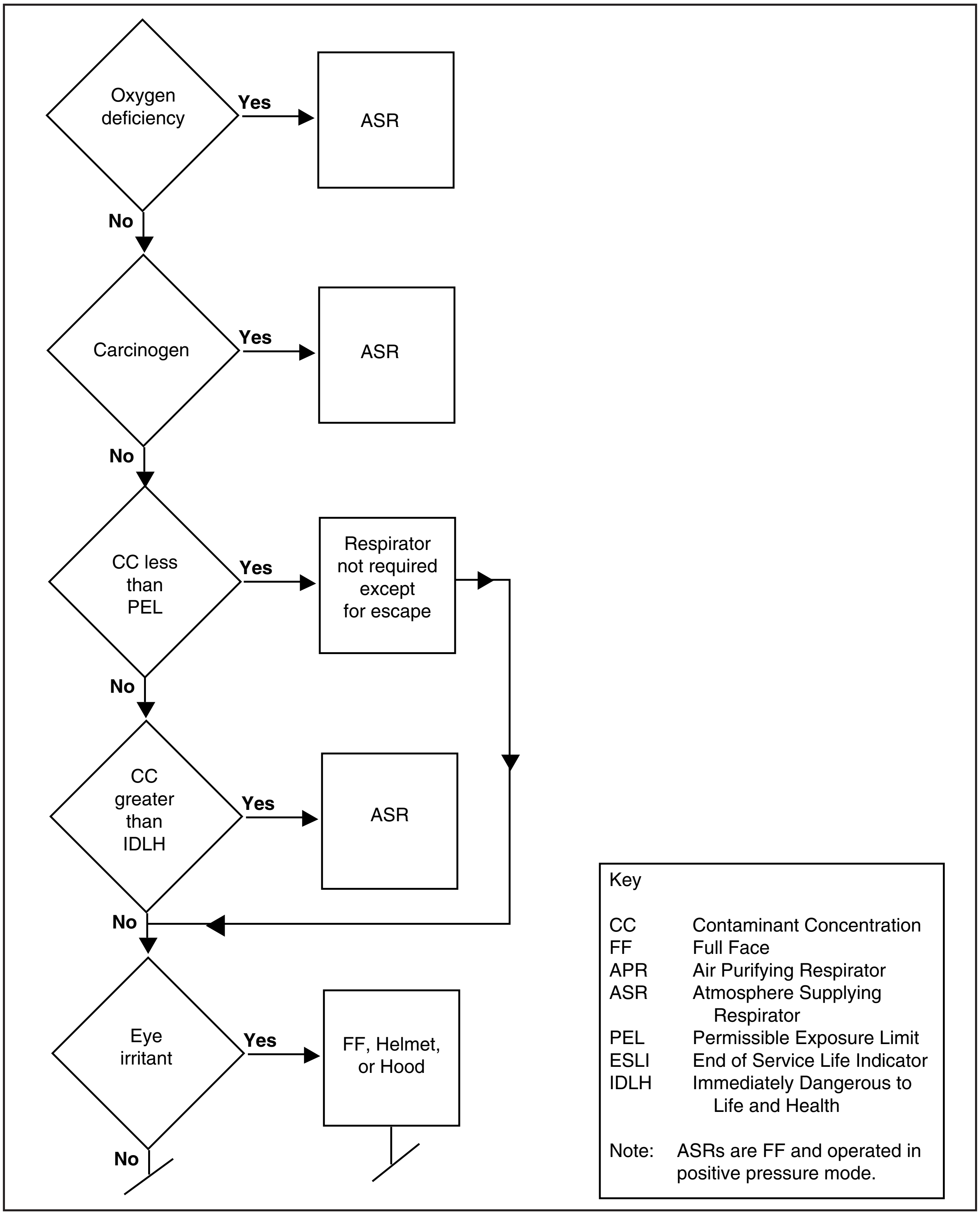


Figure 5-15. Respirator Decision Flow Chart

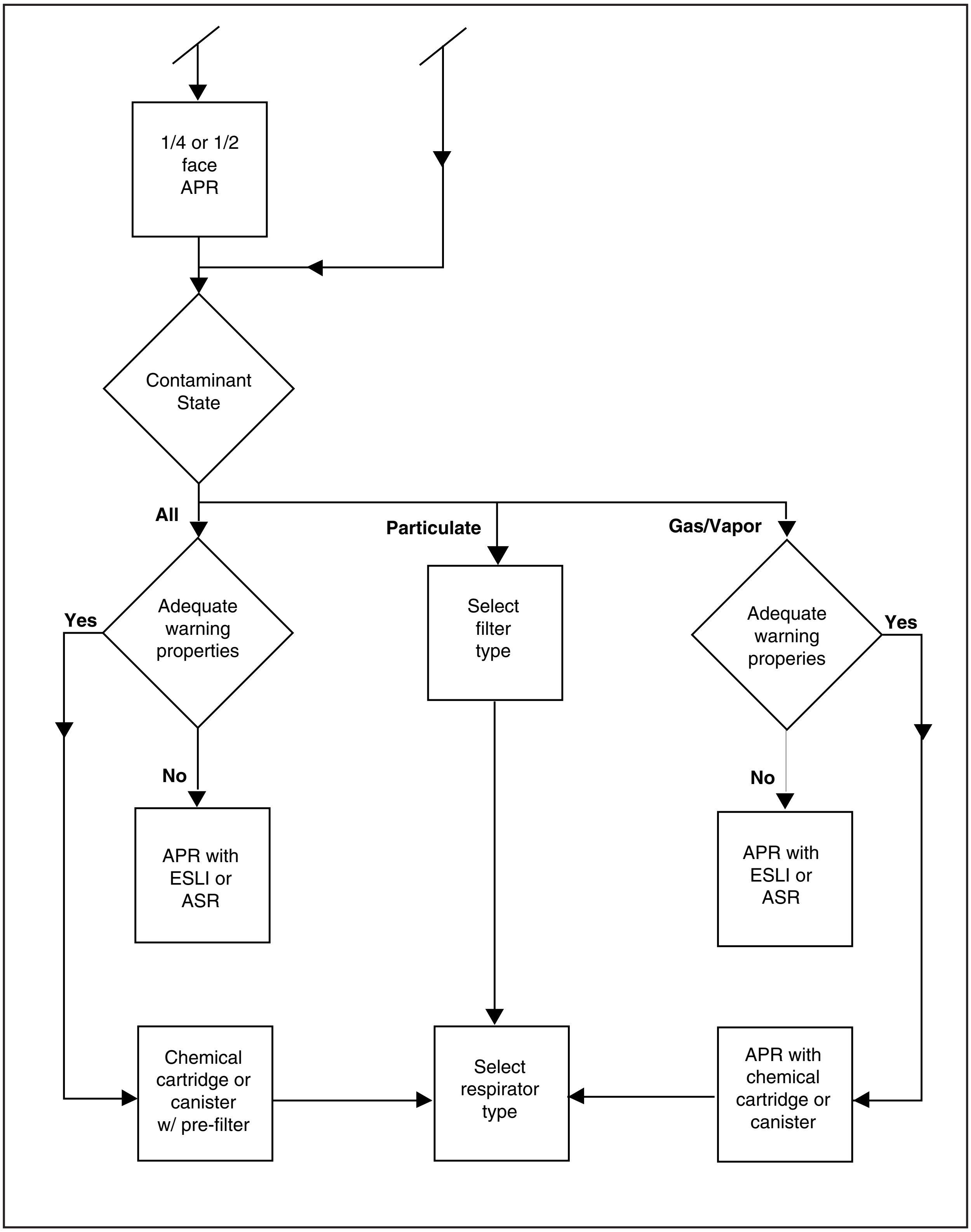


Figure 5-15. Respirator Decision Flow Chart (continued)

Section
6

ASBESTOS ABATEMENT WORKER REFRESHER

Title

SITE SAFETY

TRAINEE OBJECTIVES

After completing Section 6, you will be able to:

1. Define the following acronyms or terms:

   Accident
   Confined space
   Engineering controls
   GFCI
   Hazardous atmospheres
   HEPA
   Hygiene facilities
   LFL
   Negative exposure assessment
   Personal hygiene
   UFL

2. List the two ways to prevent accidents on the job site.

3. List the four examples of work practices that will limit exposure during asbestos abatement.

4. List the five most important actions for eliminating the risk of electrocution.

5. List the five things that should be checked on a regular basis prior to using a ladder.

6. Describe safe work practices when working with scaffolds.

7. List four examples of work practices that will help eliminate slips, trips, and falls on the job site.

8. List the four forms of heat stress and give the signs and symptoms of each.

9. List the five systems used in fall protection.

10. List the four actions a worker should take to prevent heat stress.

11. List the four actions an employer should take to prevent a worker from developing heat stress.

12. Describe how to monitor pulse, temperature, and weight.

13. List the three characteristics of a confined space.

14. List the three types of hazardous atmospheres.

15. Describe the three rules to always follow when working in hazardous atmospheres.

16. List the eight essential elements of any basic comprehensive confined space entry procedure.

17. List the nine essential items of a written emergency action plan and a fire prevention plan.

18. List the three control measures required by OSHA standards to reduce worker exposure to asbestos. Describe one control measure that is **not** allowed.

19. List the 10 steps for entering the work area.

20. List the 10 steps for exiting the work area.

INTRODUCTION

Due to the nature of the work, asbestos abatement workers face a higher risk of accidents and injury than the typical construction worker. The *personal protective equipment* (*PPE*) worn to reduce asbestos exposures can increase the accident potential by:

- Reducing dexterity
- Narrowing the field of vision and reducing clarity
- Reducing communication and hearing capabilities
- Increasing heat stress
- Increasing reaction time by causing physical and mental stress

ACCIDENTS

An *accident* is an undesirable, unplanned event resulting in personal physical harm, damage to property, or interruption of business.

Preventing Accidents

The following are two main approaches to reducing or preventing accidents:

1. Eliminate unsafe conditions
2. Reduce unsafe acts

Eliminate Unsafe Conditions

You must look for conditions that can contribute to an accident and then work to remove exposure to these conditions. Examples of removing exposure are enclosing live electrical circuits and using proper PPE. This approach is best, but it is difficult to eliminate all unsafe conditions. It is even more difficult to predict or anticipate where such conditions may exist or develop on an asbestos abatement job.

Reduce Unsafe Acts

Each worker must make a conscious effort to work safely despite the hazardous conditions that may exist at any site. You must also maintain a high degree of safety awareness so that the safety factors involved in a job become an actual part of the job.

GENERAL SAFETY

Being safe is being free from danger, harm, or injury. To be safe, you should act in two ways: offensively and defensively. When you act offensively, you continually monitor controllable actions. When you act defensively, you maintain an awareness of actions or situations that can be created by others or by actions taking place.

Safety procedures that you are familiar with from your previous work experiences deal with:

- Eye protection
- Grounding electrical equipment
- Hand tools
- Hearing protection
- Ladders
- Lifting
- Safety belts
- Safety shoes and hard hats
- Scaffolding

Safe Work Practices

Safe work practices are those work habits you use to protect yourself on the job site while performing specific duties. Many of the safe work practices used during asbestos abatement are designed to limit exposure to asbestos-containing material (*ACM*).

The following examples of work practices apply to most asbestos abatement jobs:

- Using wet removal techniques
- Using negative pressure air filter systems
- Building a polyethylene (poly) chamber and other containment barriers
- Cleaning the work area regularly

General Site Safety

General site safety procedures include using engineering controls, safe work practices, and PPE. Employing all available and possible protective measures provides a safer working environment for all workers.

ELECTRICAL SAFETY

The use of wet methods increases the chances for electrical shock when working around electrical panels, conduits, light fixtures, alarm systems, junction boxes, computers, transformers, etc.

Actions to Take

There are a number of work practices to follow to decrease the possibility of electrical accidents when using wet removal techniques. The following are actions you can take to protect yourself:

1. Always perform a pre-work walk-through to identify potential electrical hazards for abatement workers and to check for equipment that can be damaged by wet removal methods.

2. Make sure all electrical equipment in use has a *ground fault circuit interrupter* (*GFCI*) before the job starts.

3. Deenergize as much equipment as possible.

4. Consider using dry removal in areas immediately adjacent to energized electrical equipment if deenergizing is not feasible. Do this only with prior permission from the Environmental Protection Agency (*EPA*).

5. Wear heavy insulated rubber boots and gloves when working around energized wiring or equipment.

6. Use nonconductive scrapers and vacuum attachments (wood, plastic, rubber).

7. Do not violate insulated electrical coverings with scrapers, scaffolding wheels, etc.

8. Put hot line covers over energized cables and power lines when possible.

9. Do not allow water to accumulate in puddles on work area floors. Some specifications require damp floors, but not deep water.

10. Avoid stringing electrical wiring across floors. When possible, elevate wiring to keep it away from water on

the floor and to prevent damage from foot traffic and rolling scaffolds.

11. Ensure electrical outlets are tightly sealed and taped to avoid water infiltration.

12. Use nonconducting wooden or fiberglass ladders. Do **not use** metal ladders.

13. Determine operating voltages of equipment and lines before working on or near energized parts.

14. Consider electrical equipment and lines to be energized, unless tested and determined otherwise.

15. Insulate and guard energized parts from worker contact and any other conductive objects.

16. Ensure extension cords used with portable electric tools and appliances are the three-wire type and connected to a GFCI.

Extension Cords

Safety concerns arise when extension cords are used to connect equipment to a distant electrical source. Safe work practices include the following:

1. Protect cords from accidental damage.

2. Do not fasten cords with staples, hang from nails, use while still coiled, run underneath poly, or suspend by wire. The use of tape is acceptable.

Portable Hand Tools

Safe work practices are essential when working with portable electrical hand tools while using wet removal methods. Portable electrical hand tools should:

- Only be used with local exhaust ventilation to capture fibers.

- Be equipped with a three-wire cord with a ground wire permanently fixed to the tool frame.

- Be double-insulated and labeled as such.

Electrical Circuits of +600 Volts

If electrical disconnects for circuits over 600 volts are not visible and open or are not locked out, the following requirements must be met:

- Clearly identify circuits to be deenergized and isolate them from all energy sources.
- Receive notification from a designated worker that all switches and disconnects that could supply energy have been deenergized, locked out, and plainly tagged.
- Perform visual inspections and tests to ensure lines and equipment are deenergized.
- Apply protective grounds to disconnected lines or equipment.
- Attach a separate tag and lockout for each crew requiring deenergizing of the same line or equipment.

  Note: Do not remove tags from completed work until designated workers report that all crew members are clear and that protective grounds they installed have been removed.

LADDERS AND SCAFFOLDS

Asbestos abatement projects always present risks to you from falls, slips, or trips. Some of these accidents result from the use of scaffolds and ladders, which are almost always needed to do the job.

Ladders

Adhere to the following maintenance and good work practices when using ladders:

- Maintain ladders in good condition.
- Perform periodic complete inspections.
- Do not improvise repairs or use defective ladders.
- Ensure that safety feet spreaders and other ladder components are in good condition. (Missing safety feet create sharp edges that will cut poly floor covers.)

- Ensure that movable parts operate freely without binding or undue play.
- Keep rungs free of grease or oil.
- Use ladders only for their intended purpose. Ladders should not be used as platforms or walk boards.
- Ensure that extension type ladders are used with a 1:4 lean ratio (1 foot out for every 4 feet of elevation).
- Fully open step ladders before using.
- Face the ladder while going up and down.
- Do not use the top of a ladder as a step. If necessary, use a longer ladder.
- Do not use the bracing on the back legs for climbing.
- Ensure that only one person at a time uses a portable ladder.
- Secure all ladders to prevent displacement during use.
- Ensure that all ladders have well designed safety shoes.
- Positively secure hook or other type ladders used in structures.
- Select wood or fiberglass ladders to avoid electrical hazards of metal ladders.

Scaffolds

OSHA standards require that when freestanding mobile scaffolds are used, the height shall not exceed four times the minimum base dimension. This requirement is based on the fact that scaffolds are easily tipped over. Because relatively little force is required to tip a scaffold, it becomes important to make sure that wheels on mobile scaffolds turn freely and are lubricated. All components, such as crossbracing, railings, pin connectors, planking or scaffold grade lumber, should be available before the units are assembled.

According to OSHA, workers may not ride on mobile scaffolds unless the following conditions exist:

- The surface on which the scaffold is moving is within 3 degrees of level and is free of pits, holes, and obstructions.
- The height-to-base width ratio of the scaffold is 2:1 or less unless specially designed.
- Outrigger frames are installed on both sides of the scaffold.
- The propelling force in a power system is applied directly to the wheels and does not produce a speed greater than 1 foot per second.
- Workers must not be on any part of the scaffold that extends beyond the wheels, casters, or other supports.

Slips, Trips, and Falls

Areas sealed with poly and kept damp to reduce airborne fibers become very slick. Disposable booties are a potential trip hazard. Air and electrical lines also create tripping hazards. All of these conditions create potential worker hazards, even before removal begins. When asbestos and other debris are removed, the accumulations should be bagged and removed from the floor as soon as possible. This simple step, which may require more initial effort, will make cleanup easier and the overall job far safer.

GENERAL WORK PRACTICES SUMMARY

Safe work practices, if followed faithfully, will decrease the risk to you and your co-workers. A summary of these work practices follows:

- Consider the height of the work, equipment in use, and any trip hazards. Observe walking surfaces.
- The use of disposable booties may be impractical in many removal situations. They may come apart and create a serious trip hazard. Seamless rubber boots, slip-on shoes, or safety shoes with nonskid soles may be an alternative, depending on the job.

- Inspect ladders and scaffolding for unsafe conditions. Make sure railings are adequate on scaffolds.

- Minimize water on floors. Wet poly is very slick, and water increases the risk of electrical shock.

- Use care around air lines and electrical cords.

- Use tape to hang electrical lines/cords when possible.

- Never run or jump in work areas.

- Minimize debris on floors.

- Pick up tools, scrapers, and other equipment.

FALL PROTECTION SYSTEMS

As with any construction site, falls are a hazard on a asbestos abatement site. Wearing PPE can increase the risk of falls or make a fall more dangerous. Under 29 CFR 1926, Subpart M, OSHA requires that fall protection systems be used to protect workers when working at heights. These systems include the following:

- Guardrails
- Personal fall arrest devices
- Positioning devices
- Safety nets
- Safety monitoring systems

Guardrail Systems

If an employer chooses to use guardrail systems to protect workers from falls, the systems must meet the following criteria:

- Toprails and midrails shall be at least 1/4-inch thick.

- If wire rope is used for toprails, it shall be flagged at not more than 6-foot intervals with highly visible material.

- Steel banding and plastic banding shall not be used on toprails or midrails.

- Manila, plastic, or synthetic rope used for toprails or midrails is shall be inspected frequently.

Structure

The highest part of the toprail shall be 42 inches, ±3 inches above the working surface. When midrails are used, they shall be installed at a height midway between the toprail and the working level.

Projections

Guardrail systems shall be smooth to protect workers from punctures or lacerations and to prevent PPE from snagging. The ends of toprails and midrails shall not overhang terminal posts, except when the overhang does not create a projection hazard.

Walking/Working Surfaces

In hoisting areas, a chain, gate, or removable guardrail section must be placed across the opening when hoisting operations are not taking place.

At holes, guardrail systems must be set up on all unprotected sides or edges. When holes are used for passing materials, they shall have no more than two sides with removable guardrail sections. When a hole is not in use, it must be covered or provided with guardrails along all unprotected sides or edges.

Guardrail systems can be used around holes that are access points, such as ladderways. The guardrail must have gates, or the point of access must be offset to prevent workers from accidentally walking into the hole.

If guardrails are used at unprotected sides or edges of ramps and runways, they must be erected on each unprotected side or edge.

Personal Fall Arrest Systems

A personal fall arrest system consists of an anchorage, connectors, and body harness. It may also include a deceleration device, lifeline, or suitable combinations. If a personal fall arrest system is used for fall protection, it must do the following:

- Limit maximum arresting force on a worker to 1,800 pounds when used with a body harness.
- Be rigged so that a worker cannot free fall more than 6 feet or contact any lower level.
- Bring a worker to a complete stop within 3 1/2 feet.
- Have enough strength to withstand twice the impact energy of a worker falling a distance of 6 feet.

Note: Per OSHA, the use of body belts for fall arrest is prohibited as of January 1, 1998.

Personal fall arrest systems must be inspected prior to each use for wear damage and other deterioration.

Self-retracting life lines and lanyards which automatically limit free fall distance to 2 feet or less shall be capable of sustaining a minimum tensile load of 3,000 pounds applied to the device in the fully extended position.

Self-retracting life lines and lanyards which do **not** limit free fall distance to 2 feet or less, rip stitch lanyards, and tearing and deforming lanyards shall be capable of sustaining a minimum tensile load of 5,000 pounds applied to the device with the lifeline or lanyard in the fully extended position.

Anchorages used to attach personal fall arrest systems shall be independent of any anchorage being used to support or suspend platforms. Personal anchorage points, lanyards, and vertical life lines must be capable of supporting at least 5,000 pounds per person attached.

Positioning Device Systems

Positioning device systems must meet these provisions:

- They shall be rigged so that a worker cannot free fall more than 2 feet.
- They shall be secured to an anchorage capable of supporting at least twice the potential impact load of a worker's fall or 3,000 pounds, whichever is greater.

Safety Net Systems

Safety net systems must be installed as close as possible under the working surface, but never more than 30 feet below such levels.

Safety nets shall be inspected:

- At least once a week for wear, damage, and other deterioration.
- After any occurrence that could affect the integrity of the safety net system.

The maximum size of each safety net mesh opening shall not exceed 6 inches x 6 inches. All mesh crossing shall be secured to prevent enlargement of the mesh opening.

Each safety net or section of it shall have a border rope for webbing with a minimum breaking strength of 5,000 pounds.

Connections between safety net panels shall be as strong as integral net components and be spaced no more than 6 inches apart. Safety nets shall be installed with sufficient clearance underneath to prevent contact with the surface or structure below. They shall be capable of absorbing the impact of a 400-pound drop test from the highest walking/working surface at which workers are exposed to fall hazards, but not less than 42 inches above that level.

Items that have fallen into safety nets, such as scrap, equipment, and tools, must be removed as soon as possible or at least before the next work shift.

Safety Monitoring Systems

The safety monitoring system is a system in which a competent person is responsible for recognizing and warning workers of fall hazards.

This safety monitor shall:

- Be competent in recognizing fall hazards.
- Warn workers when it appears they are unaware of a fall hazard or are acting unsafely.
- Operate on the same walking and working surface as the workers and shall be able to see them.
- Be close enough to work operations to communicate verbally with workers.
- Have no other duties except monitoring.

Other provisions of the safety monitoring system include:

- Mechanical equipment shall not be used or stored in areas where safety monitoring systems are used.
- Workers shall not be allowed in an area where a worker is being protected by a safety monitoring system, unless they are engaged in roofing work (on low-sloped roofs) or covered by a fall protection plan.
- Workers in a *controlled access zone* shall be instructed to comply promptly with fall hazard warnings issued by safety monitors.

A controlled access zone is an area in which certain work may take place without the use of guardrail systems, personal fall arrest systems, or safety net systems.

Training

Employers must provide a training program that teaches workers who might be exposed to fall hazards how to recognize such hazards and how to minimize them. They must issue written certification that identifies the worker as trained and the date of the training.

HEAT STRESS

Heat can be a serious hazard on an asbestos abatement job, especially in crawl spaces and boiler rooms. If you will be exposed to excessively hot environments, an extensive program specifying safe work practices should be established before starting the work. In general, the hotter and more strenuous the job, the greater the chance of *heat stress*.

The severity of heat stress depends on many factors, including:

- Environmental conditions, such as air temperature, air movement, and relative humidity.
- Worker's age, degree of physical fitness, and obesity.
- Degree of acclimatization (i.e., workers in winter are less acclimated to heat, and thus, more susceptible).
- Type of clothing worn.

Workers Who Are at Risk

Workers who are particularly susceptible to heat stress include those who are:

- Wearing protective clothing.
- Suffering from diarrhea or fever.
- Not physically fit, are obese, or have not acclimated (become accustomed) to the environment.
- Suffering from a chronic diseases, such as heart disease or diabetes.
- Smokers or those who drink excessive alcohol or use drugs.
- Regularly taking certain medications for depression, nervous conditions, high blood pressure, diabetes, or heart disease.

Forms of Heat Stress

There are four forms of heat stress that result from exposure to high temperatures. The four categories of heat stress are:

1. Heat rash
2. Heat cramps
3. Heat exhaustion
4. Heat stroke

Heat Rash

Heat rash is the mildest form of heat stress. It is how the body reacts to hot and humid environments. It is caused by heavy sweating where sweat cannot be easily removed by skin evaporation. The symptoms of heat rash are:

- Reddening of the skin
- Blisters or a rash

Heat Cramps

Heat cramps are due to heavy sweating with inadequate electrolyte replacement. Signs and symptoms include:

- Muscle spasms
- Pains in the hands, feet, and abdomen

Cramps are usually in the extremities, and generally, follow heavy exertion. However, they may also take place hours later. If heat cramps occur, you should rest in a cool place and increase fluid intake.

Heat Exhaustion

Heat exhaustion is the result of dehydration (not drinking enough fluids) or cardiovascular insufficiency (being generally unfit). Signs and symptoms include:

- Dizziness
- Nausea
- Normal-to-low temperature
- Heavy sweating
- Pale, cool, moist skin
- Rapid pulse and breathing
- Fainting

Heat Stroke

Heat stroke is the most serious heat stress disorder. It results from failure of the body's ability to regulate temperature. Signs and symptoms include:

- Dizziness
- Confusion
- High fever
- No sweating
- Red, hot, dry skin
- Strong, rapid pulse
- Convulsions
- Coma
- Death

The onset of heat stoke can be gradual, with mental excitement and dryness of mouth and skin, or it can be sudden, with delirium, stupor, or coma. **Heat stroke has a death rate of 30 to 50 percent.**

Table 6-1 summarizes the four forms of heat stress and their signs and symptoms.

TABLE 6-1

SIGNS AND SYMPTOMS OF HEAT STRESS

Types of Heat Stress	**Cause**	**Signs/Symptoms**
Heat rash	Heavy sweating when sweat is not easily removed by skin evaporation.	Redness on skin Blisters or a rash
Heat cramps	Heavy sweating with inadequate electrolyte replacement.	Muscle spasms Pain in hands, feet, and abdomen
Heat exhaustion	Increased stress on various body organs and the circulation system. Caused by the inability of the the heart to work properly and/or dehydration.	Dizziness Nausea Normal to low temperature Heavy sweating Pale, cool, moist skin Rapid pulse and breathing Fainting
Heat stroke	**Heat stroke is the most serious form of heat stress.** Temperature regulation fails. Body temperature rises to critical levels, as high as 108° to 112°F. The body **must** be cooled immediately before serious injury or death occurs. **Competent medical help must be obtained.**	Dizziness, confusion Nausea High fever Little or no sweating Red, hot, usually dry skin Strong, rapid pulse Convulsions Coma Death

Preventive Measures

You can reduce your susceptibility to heat stress when working in a hot environment by applying preventive measures. These include the following:

- Enclose or ventilate equipment or processes generating heat or steam.
- Use exhaust ventilation to draw heat from the area. Have HEPA exhausts in the hottest areas. Supply the area with colder air.

  Note: Fans are not recommended when loose material is present because dusts or particulates will become airborne.
- Implement short work periods in the hot environment and long rest periods in a cool area. It may be necessary to have up to 75 percent rest time depending on work conditions.
- Drink plenty of water to replace lost fluids, even if you are not thirsty. Avoid drinking alcohol because it can lead to further dehydration.
- Slowly acclimate to the hot environment. Acclimatization is the process by which our bodies adjust to hot environments. Gradual exposure to a hot environment works best.

Monitoring for Heat Stress

You can reduce your risk of heat stress by regularly monitoring your heart rate, temperature, weight, and by using the following guide lines:

- Check your heart rate during rest breaks. If it is greater than 120 beats a minute, work time should be reduced and rest time increased. A normal pulse (heart rate) is 50 to 100 beats a minute.
- Check your temperature at the end of the work period but before drinking fluids. If it is greater than 99.6°F (37.6°C), work time needs to be reduced and rest time increased. If it is greater than 100.6°F (38.1°C), remove protective work clothing. (Normal body temperature is usually 98.6°F.)

- Check your weight (in the nude) before and at the end of work. If weight loss is greater than 1.5 percent of total weight, drink more fluids during work. For example, to calculate 1.5 percent of total weight:

Normal weight	=	200 pounds
200 x .015	=	3 pounds

  If you lose more than 3 pounds in one work shift, drink more fluids.

- Check regularly for symptoms of heat stress and seek treatment when necessary.

Treatment/Emergency Measures

Heat stress can be a life-threatening situation. If you or a co-worker are suffering from heat stress, follow these emergency measures:

- Get medical help immediately. Emergency telephone numbers should be posted at the work site.
- Move the victim to a cool, uncontaminated area. Remove the worker's respirator if he or she is wearing one.
- Cool the victim by soaking clothes thoroughly with water, removing clothes, and/or vigorously fanning.

CONFINED SPACE ENTRY

A *confined space* is an area that has any one or all of the following characteristics:

- Adequate size and shape to allow a person to enter
- Limited openings for entry and exit
- Not designed for continuous human occupancy

Typical examples of confined spaces include:

- Storage tanks
- Tank trucks
- Process vessels
- Boilers
- Pipelines
- Pits
- Septic tanks

- Vats
- Manholes
- Utility vaults
- Ventilation ducts
- Silos
- Sewers
- Trenches

Confined Space Hazards

The primary hazards found in confined spaces are:

- Hazardous atmospheres
- Moving or driven equipment
- Process liquids and steam or water

Hazardous Atmospheres

Because there is a lack of natural air movement in most confined spaces, the most common hazard is hazardous atmospheres. There are three types of hazardous atmospheres you should recognize:

- Oxygen-deficient atmospheres
- Flammable atmospheres
- Toxic atmospheres

Oxygen-deficient Atmospheres

An oxygen-deficient atmosphere has less than 19.5 percent available oxygen. You should not enter any atmosphere with less than 19.5 percent oxygen without an approved self-contained breathing apparatus (*SCBA*) or a supplied air respirator with an escape SCBA. Even if testing shows oxygen levels above 19.5 percent, remember there is normally a lack of ventilation or natural air movement in a confined space.

Flammable Atmospheres

A flammable atmosphere develops when a flammable gas, vapor, or dust is present in the air at concentrations between the lower flammable limit (*LFL*) and the upper flammable limit (*UFL*). An explosion will result if a source of ignition (e.g., a sparking electrical tool) is introduced into a confined space containing a flammable atmosphere.

Toxic Atmosphere

Most substances (liquids, vapors, gases, mists, solid materials, and dusts) should be considered hazardous in a confined space. The following are some sources of *toxic* substances that can be present in confined spaces:

- Liquids, residues, or sludges from previously stored material.

- Toxic materials that have been absorbed into the walls and can give off toxic gases or vapors.

- Hazardous gases produced by decomposition.

- Hazardous gases that have accumulated at the bottom of the confined space because they are heavier than air.

- Materials produced by, or used in, the work being performed in the confined space. For example: cleaning solvents, paints, and welding fumes.

Hazardous Atmosphere Work Practices

In view of the extremely hazardous atmospheres that can exist in confined spaces, you should always follow these safe work practices:

- Never enter a confined space if it contains flammable vapors or gases greater than 10 percent of the lower explosive level (*LEL*) or LFL, or if the concentration of a toxic material is *immediately dangerous to life and health* (*IDLH*).

- Always wear an approved SCBA when entering an atmosphere with less than 19.5 percent oxygen.

- When concentrations of toxic materials are above 50 percent of the permissible exposure limit (*PEL*), but below the IDLH, you may enter if you are wearing the appropriate PPE.

Reducing the Danger

The following procedures will reduce the dangers associated with confined spaces:

- Isolation
- Testing the atmosphere
- Ventilation
- Standby and rescue

Isolation

Isolation of a confined space eliminates the hazards associated from moving or driven equipment, and the unexpected entry of process liquids, steam, or water.

Isolation is the process whereby the space is removed from service by:

- Locking out electrical sources, preferably by disconnecting the switches from the equipment.
- Blanking and bleeding lines that contain process fluids, steam, and water or pneumatic and hydraulic lines.
- Disconnecting or locking out drives on mechanically driven equipment.
- Securing moving parts within the confined space with latches, chains, locks, or other devices.

Testing the Atmosphere

It is important to understand that some gases or vapors are heavier than air and will initially settle to the bottom of a confined space. Also, some gases are lighter than air and will initially be found around the top of the confined space. Therefore, it is necessary to test all areas—top, middle, and bottom—of a confined space with properly calibrated testing instruments to determine what gases are present.

Ventilation

Ventilation by a blower or fan may be necessary to remove harmful gases and vapors from a confined space. There are several methods for ventilating a confined space. The method and equipment chosen depend on the following:

- Size of the confined space openings
- Hazardous gases to be exhausted
- Source of the makeup air

A common method of ventilation requires a large hose with one end attached to a blower and the other placed into the confined space. For example, to ventilate a manhole, the ventilating hose would be run to the bottom to blow out all harmful gases and vapors. The air intake would be placed in an area that would only draw in fresh air. Ventilation should be continuous, because in many confined spaces the hazardous atmosphere will form again when the flow of air stops.

Standby and Rescue

An attendant must remain on the outside of the confined space and be in constant contact (visual or voice) with the workers inside. The attendant shall not perform any duties that might interfere with the primary duty of monitoring and protecting the authorized entrants. The attendant must know whom to notify in case of an emergency. Attendants shall not enter a confined space until help arrives and then only if they are trained and have proper equipment.

Rescuers must be trained in, and follow, established emergency procedures and use appropriate equipment and techniques, including:

- Life lines
- Respiratory protection

Steps for safe rescue should be included in all confined space entry procedures. Rescue procedures should be well planned and drills frequently conducted on emergency procedures.

Confined Space Entry Procedure

There are eight basic elements of any comprehensive confined space entry procedure, as follows:

1. Authorization and permit - No person should enter a confined space unless a confined space entry permit has been prepared and authorized by the entry supervisor.

2. Pre-entry precautions - Ensure that the confined space has been isolated to prevent entry of hazardous materials. Methods include:

   - Locking out and tagging
   - Removal of spool pieces
   - Installation of blanks

   Lock out and tag out all associated electrical and mechanical equipment.

3. Pre-entry testing - Confined spaces shall be tested for hazardous atmospheres, including, as a minimum:

   - Oxygen deficiency (percentage of oxygen)
   - Flammable vapors (percentage of LEL)
   - Toxic materials (concentration of unknown contaminant)

   Results of testing (instrument readings) shall be noted on the entry permit.

4. Entry decision - No one may enter a confined space until all items on the confined space entry permit are completed and signed. Appropriate authorization signatures must be in place.

5. Standby attendant - Workers working in a confined space must be under the constant observation of an attendant who is outside the confined space. The attendant must review the checklist before permitting any confined space entry.

6. Rescue harness - Every worker entering a confined space must wear a rescue harness or wristlets with a lifeline attached. The end of the lifeline must be secured outside the confined space.

7. Dangerous atmosphere - Where an oxygen deficiency or a potential fire hazard exists, or could develop, all workers within the confined space must wear SCBAs.

8. Emergency actions - In the event of an emergency, the attendant must:

   - Never enter the confined space.

   - Promptly sound alarm or communicate the emergency to emergency personnel.

   - Leave his or her post only to report emergency or for self-protection.

FIRE SAFETY

Fire safety concerns include exits, travel distances, emergency lighting, and alarm systems.

OSHA Fire Standards

OSHA fire standards regulate protective clothing, containment, and sheeting materials. It is important to know that some protective clothing will burn and melt quickly. It can shrink, adhere to skin, and rip as it burns. Heavy black smoke is a combustion by-product. Polyethylene and other fabric type containments are combustible. They start burning slowly and pick up speed as more heat is generated, giving off heavy smoke as the fire progresses. Flame spread is slow and steady. Sheeting should be kept away from heat sources, such as transformers, steam pipes, and boilers that will be heated during removal. (Polyethylene should not be allowed to come in contact with surfaces above 150°F.)

Avoiding Fire Problems in Control Areas

As with other safety issues, it is far preferable to avoid fire entirely. However, in case of fire, the fire hazard becomes more immediate than the asbestos hazard, and you may need to break the barriers. This should be communicated to all workers in the emergency action plan for the job site. Other measures for avoiding fire are to:

- Ensure all sources of ignition are removed. Be sure that gas and other fuel sources are cut off and that pilot lights in boilers, heaters, hot water tanks, and compressors are extinguished.
- Locate hot spots. Often equipment will have to be draped instead of sealed off to prevent overheating (e.g. computers, terminal boards, switch panels, transformers).
- Cut off supply to steam lines, electric and steam heaters, and radiators. Do not permit the poly to come in contact with hot surfaces.
- Do not allow lighters or matches into the work area.
- Strictly enforce no smoking, eating, or drinking rules inside the work area.
- Provide lighting in exits and exit routes.

- Post a fire watch along with the appropriate fire extinguisher when using an oxyacetylene torch for cutting. Do not use CO_2 extinguishers in confined or enclosed spaces. Dry chemical extinguishers are effective, but the powder is a respiratory irritant.

- Use sheet metal or a treated tarp to catch sparks when using a cutting torch. Be aware of what is on the other side of the wall and under the floor.

- Reduce the amount of flammable and combustible materials inside a space to a minimum before hanging plastic. This includes removal of any chemicals, flammable liquids, and heat sensitive materials.

- Mark exits from the work area. Post directional arrows when exits are not visible from remote work areas. This can be done easily by using duct tape on the polyethylene walls and barriers.

- Keep trash and debris to a minimum, such as tape, poly, bags, and lumber.

- Have several emergency exits if the work area is large and many workers are present. Choose exits that are locked from the outside but can be opened from the inside. A daily inspection should be conducted to ensure secondary exits are not blocked.

- Be alert for flammable vapors in industrial areas such as solvents, including naphtha, toluene, and xylol. This is especially critical in industrial vacuuming operations, where vacuum motors are not explosion proof. Compressed air vacuums may be required.

- Ensure a telephone is available at all times for notifying authorities in an emergency.

- Post local fire department and rescue squad phone numbers. Advise them of the operations in progress.

- Make sure there is a monitor trained in emergency procedures outside at all times. Likewise, someone should be trained in first aid, including the treatment of heat stress and burns.

Written Emergency Action and Fire Prevention Plans

The OSHA fire safety standard requires a written emergency action plan and a fire prevention plan. Briefly, the nine essential elements of the plans include:

1. The manner in which emergencies are announced.

2. Emergency escape procedures and emergency escape routes.

3. Procedures for workers who must remain to operate critical plant operations that may take time to shut down.

4. Procedures to account for all workers after evacuation.

5. Rescue and medical duties.

6. Names and/or job titles of individuals to contact for additional information.

7. A list of the major workplace fire hazards.

8. Names and/or job titles of individuals to contact for maintenance of fire prevention equipment.

9. Names and/or job titles of individuals responsible for the control of fuel source hazards.

AIR SAMPLING

At the beginning of any construction job where there is ACM, air sampling must be done to determine worker exposure. This sampling must include personal air samples from each work area, reflecting worker exposure averaged over an eight-hour period. This initial monitoring must be done to determine that workers' asbestos exposure during an operation is below the PEL. The term used for this is referred to as a *negative exposure assessment (NEA)*.

OSHA defines an NEA as "a demonstration by the employer that worker exposure during an operation is expected to be consistently below the PEL." The employer does this by having the *competent person* (as defined by OSHA) conduct an exposure assessment (monitor the air) before or at the start of an operation involving asbestos. If the monitoring comes out negative (below the PEL), than the employer has an NEA.

NEAs are used to provide information that is necessary to ensure that all control systems in use are appropriate for the operation and that they are working properly. Control systems reduce the level of worker exposure to asbestos. Specific systems, such as a negative air machine, will be discussed in detail in other sections of this manual.

CONTROL MEASURES

Control measures required by the OSHA standards include:

- Engineering controls.
- Work practice controls, including certain work practices relating to the actual removal of asbestos, cleaning up the work site after removal, and disposal of contaminated materials and clothing. Also included are the provision and use of PPE (i.e., respirators and clothing) in specific working conditions.
- Administrative controls. The only administrative control allowed in asbestos abatement is worker training.

  Employers may **not** control worker exposure by frequently rotating people in and out of the regulated area.

The OSHA Asbestos Standard 29 CFR 1926.1101 states that on all asbestos abatement jobs, the employer must use one or any combination of the following control measures to reduce exposure to the acceptable limit of 0.1 fibers per cubic centimeter (*f/cc*):

- Local exhaust ventilation equipped with a HEPA filter system.
- Enclosure or isolation of processes producing asbestos.
- Use of wet methods, wetting agents, or removal encapsulants.

- Prompt disposal of asbestos-contaminated waste in leak-tight containers.

- The use of other feasible work practices or engineering controls.

Where exposure cannot be reduced to 0.1 f/cc, respiratory protection must be provided as well.

Exposure Limits and Labeling

The average worker exposure over an 8-hour period must be no greater than 0.1 f/cc of air. If exposure limits exceed 0.1 f/cc of air, the area must be marked to restrict entrance and regulated to ensure proper protection of all entering workers. This area is referred to as the regulated area. Regulation of the area involves:

- Implementing proper control measures
- Providing respirators to all entering workers
- Prohibiting eating, drinking, smoking, and chewing gum in the area

All materials releasing asbestos fibers must be specifically labeled. Figures 6-1 and 6-2 are example of warning signs.

DANGER ASBESTOS
CANCER AND LUNG DISEASE HAZARD
AUTHORIZED PERSONNEL ONLY
Respirators and Protective Clothing
are Required in this Area

Figure 6-1. This is an example of the warning sign that should be posted at a work site.

DANGER
CONTAINS ASBESTOS FIBERS
AVOID CREATING DUST
CANCER AND LUNG DISEASE HAZARD

Figure 6-2. This is an example of the warning sign that must be posted on all disposal bags.

Short Duration Abatement

The National Emission Standards for Hazardous Air Pollutants (*NESHAP*) and the EPA generally define a small scale, short duration job as an abatement project involving less than 3 linear feet or 3 square feet of ACM or no more ACM than it would take to fill one *glove bag*.

Engineering Controls

An *engineering control* is an exposure control in which exposure is reduced through mechanical means, such as ventilation systems, decontamination areas, and containment devices.

Ventilation System – Negative Pressure Enclosure

Negative pressure is created by a ventilation system within an enclosure that acts like a vacuum, drawing the dust from inside the area out through the ventilation system. The ventilation system must be equipped with HEPA filters to make sure that asbestos fibers in the air are filtered out and not released to the outside air. This system must operate 24 hours a day during the entire project. A pressure of -0.02 inches of water should be maintained. A pressure gauge for measuring the air pressure should be installed and regularly checked by the competent person.

A negative pressure enclosure must be set up before starting all Class I and Class II and some Class III asbestos removal, renovation, or demolition jobs. This does not apply to Class III or Class IV jobs, such as:

- Pipe repair
- Valve replacement
- Installation of electrical conduits
- Installation or removal of drywall, roofing, and other general building maintenance or renovation

Decontamination Areas – Hygiene Facilities

Hygiene facilities on asbestos jobs are areas where workers remove asbestos contamination from their bodies and equipment.

Class I

For Class I work, the employer must provide a decontamination unit that includes an equipment room, a shower room, and a clean change room for all asbestos removal, renovation, or demolition jobs. OSHA requires that the decontamination unit be adjacent and connected to the regulated area.

Class II and Class III

Class II and Class III asbestos work where exposures are expected to be greater than the PEL or there is no NEA, require the use of a simpler decontamination area. This area is a combination equipment room and worker decontamination area. Workers pass through this room and use a HEPA vacuum to remove the gross contamination off their protective clothing. Once this is done, the protective clothing is removed, then deposited in marked containers located in this area. Equipment removed from the work area is HEPA-vacuumed and wet wiped to remove any contamination.

Work Practice Controls

The OSHA Standard recommends certain work practices that are effective in limiting the amount of asbestos released into the air during removal.

Removal Work Practices

Recommended work practices for removal include:

- Before disturbing ACM, it should be thoroughly wet. The wetting of asbestos must be done with an amended water solution, which is more effective in soaking the asbestos fibers than plain water.
- Sprayed ACM should be removed by scraping.
- Nonsprayed asbestos material should be removed by cutting the supporting metal bands or wire mesh. Any additional material should be removed by brush or by wiping it with a wet cloth.

The EPA Standard requires that friable asbestos materials (materials with more than 1% asbestos) be removed prior to demolition or renovation unless they are on a part of the building enclosed in concrete or they are adequately wet when exposed during demolition.

ACM should be adequately wet prior to being removed from intact parts of the building. Such wetting can be avoided only on specific renovation jobs where it is determined by the administrator of the EPA that permanent damage would result.

Friable asbestos materials that have been removed must be kept wet until they are collected for disposal. All such materials must be carefully lowered to the ground. Dust-tight chutes must be constructed and used when the lowering distance is greater than 15 feet (except when whole units or sections are removed).

When a part of the building covered or coated with friable asbestos materials is being removed as a unit or in sections, all ACM exposed in the process must be wetted. Units or sections should be carefully lowered to ground level.

When removing asbestos from a building section that has been removed, either adequately wet the ACM or use a local exhaust ventilation and collection system to capture the asbestos fibers released. No visible emission of asbestos fibers is permitted.

When the temperature is below 32°F (0°C), the wetting requirements are limited to that indicated in the previous two paragraphs.

Housekeeping

Any vacuuming performed in the work area must be done with a HEPA-filtered vacuum. The equipment must be used and emptied in a way that minimizes the re-entry of asbestos into the workplace. The work area should be kept clear of asbestos debris. Asbestos waste, scrap, debris, bags, containers, equipment, and contaminated clothing shall be collected and disposed of in sealed, labeled, impermeable bags or other closed, labeled impermeable containers.

Waste Disposal

All asbestos-contaminated waste, equipment, and clothing to be discarded must be put in a sealed, labeled, leak-proof bag or container. All asbestos-containing waste material must be deposited at waste disposal sites operated in compliance with EPA disposal standards.

Prohibited Control Measures

Some engineering controls, work practices, and administrative controls are **prohibited**. They must **not** be used for asbestos-related work or for work that disturbs ACM or presumed asbestos-containing material (*PACM*) regardless of the measured levels of exposure.

Prohibited control measures include the following:

- The use of high-speed abrasive disk saws that are not equipped with point-of-cut ventilators or enclosures with HEPA-filtered exhausted air.
- Compressed air used to remove asbestos or ACM, unless the compressed air is used in conjunction with an enclosed ventilation system designed to capture the dust cloud created by the compressed air.
- Dry sweeping, shoveling, or other dry cleanup of dust and debris.
- Worker rotation as a means of reducing worker exposure to asbestos.

Personal Hygiene

A work practice control for which you are directly responsible is personal hygiene. Families of asbestos workers are often unknowingly exposed to asbestos fibers from contaminated clothing and other articles workers bring home. Following the good hygiene will greatly reduce the potential of asbestos contamination for you and your family.

ADMINISTRATIVE CONTROLS

The only administrative control permitted in asbestos abatement is worker training.

Worker Training

If you are working in areas where asbestos exposure is greater than the PEL (0.1 f/cc), you must receive training before or at the time of your first job, and once every year thereafter. In addition to providing information on recognizing asbestos and its health effects, this training must identify effective methods for controlling exposure. All written training materials must be made available to you at no charge.

SECTION 6 - ASSIGNMENT SHEET

1. Define the following acronyms or terms:

Accident ______________________________

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Confined space ______________________________

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Engineering controls ______________________________

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GFCI ______________________________

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Hazardous atmospheres ______________________________

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HEPA ______________________________

____

Hygiene facilities ______________________________

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LFL ______________________________

____

Negative exposure assessment ______________________________

____

Personal hygiene ______________________________

____

UFL ______________________________

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2. List the two ways to prevent accidents on the job site.

3. List the four examples of work practices that will limit exposure during asbestos abatement.

4. List the five most important actions for eliminating the risk of electrocution.

5. List the five things that should be checked on a regular basis prior to using a ladder.

6. Describe safe work practices when working with scaffolds.

7. List four examples of work practices that will help eliminate slips, trips, and falls on the job site.

8. List the four forms of heat stress and give the signs and symptoms of each.

9. List the five systems used in fall protection.

10. List the four actions a worker should take to prevent heat stress.

11. List the four actions an employer should take to prevent a worker from developing heat stress.

12. Describe how to monitor pulse, temperature, and weight.

13. List the three characteristics of a confined space.

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14. List the three types of hazardous atmospheres.

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15. Describe the three rules to always follow when working in hazardous atmospheres.

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16. List the eight basic elements of any basic comprehensive confined space entry procedure.

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17. List the nine essential items of a written emergency action plan and a fire prevention plan.

18. List the three control measures required by OSHA standards to reduce worker exposure to asbestos. Describe one control measure that is **not** allowed.

19. List the ten steps for entering the work area.

20. List the ten steps for exiting the work area.

ASBESTOS ABATEMENT WORKER REFRESHER

Section
7

Title
NEGATIVE PRESSURE AIR FILTER SYSTEMS FOR CLASS 1 ASBESTOS ABATEMENT

7

TRAINEE OBJECTIVES

After completing Section 7, you will be able to:

1. List the two most important goals for a negative pressure air system.
2. List the four benefits of a negative pressure air system.
3. Describe how a negative pressure air filter system creates a negative pressure, and how this reduces the concentration of airborne asbestos within the work area.
4. List the eight guidelines for constructing a negative pressure enclosure.
5. Describe how a portable HEPA-filtered negative pressure unit functions.
6. Name the three filters that are part of the HEPA-filtered exhaust unit.
7. Explain what an air change is, and how many are recommended every hour.
8. Describe where the negative pressure unit should be located within a work area, and give the reason for the placement of the unit at this location.
9. Describe how a negative pressure system is tested.
10. Describe how and when the filters of the negative pressure unit are changed.

INTRODUCTION

A negative pressure air filter system is a piece of equipment containing a series of air filters and a fan. It lowers the air pressure in the work area or makes it negative compared to the air pressure outside the work area. The *negative pressure* is created by continuously exhausting the air in the work area to the environment outside. This means that air moves into the work area from the clean area outside the chamber. The negative pressure also prevents contaminated air from leaving the work area until it is filtered. Air is filtered by a *high-efficiency particulate air* (*HEPA*) *filter* in the negative pressure air filter system to remove asbestos fibers before they are exhausted from the work area.

NEGATIVE PRESSURE AIR FILTER SYSTEMS

The two most important goals for negative pressure air systems are to:

1. Change air within the poly chamber at least every 15 minutes
2. Prevent contaminated air from leaving the work area

Four benefits of negative pressure air filter systems are:

1. Containment of airborne fibers even if the barrier is ripped or punctured.

2. Lower concentration of airborne fibers in the work area.

3. Worker comfort and increased productivity.

4. Improved efficiency in final cleanup.

NEGATIVE PRESSURE ENCLOSURE

Negative pressure enclosures must be set up before starting any Class I asbestos removal, renovation, or demolition job. Class I asbestos work includes all activities involving removal of *thermal system insulation* (*TSI*) and *surfacing material* (*SM*) that is either *asbestos-containing material* (*ACM*) or *presumed asbestos-containing material* (*PACM*).

Note: This does not apply to Class II, III, or IV jobs limited to pipe repair, valve replacement, installation of electrical conduits, installation or removal of drywall, roofing, and other general building maintenance or renovation.

The Occupational Safety and Health Administration (*OSHA*) and the Environmental Protection Agency (*EPA*) generally define a small scale, short-duration job as an abatement project involving less than 3 linear feet or 3 square feet of ACM or no more ACM than it would take to fill one glove bag.

Negative pressure is created by a ventilation system within the enclosure that acts like a vacuum, drawing dust inside the area. The ventilation system must be equipped with HEPA filters to make sure that asbestos fibers in the air are filtered out and not released to the outside air. This system must operate 24 hours a day for the entire project. A pressure of -0.02 inches of water should be maintained. A pressure gauge for measuring the air pressure should be installed and regularly checked. OSHA regulations require that before beginning work within the enclosure and at the beginning of each shift, the negative pressure enclosure must be inspected for breaches and smoke tested for leaks. If any leaks are found, they must be sealed.

Guidelines for Constructing an Enclosure

The following are guidelines for constructing an enclosure. (These procedures are not mandatory.)

1. Remove all moveable objects from the work area. Objects already contaminated with asbestos should be vacuumed with a HEPA vacuum and cleaned before removal with a water solution (amended water) particularly effective at soaking asbestos fibers.

   Note: Amended water is water that has an added wetting agent, which makes it soak into a material quickly and thoroughly.

2. Cover all objects that cannot be moved to create a tight seal. Use 6-mil thick polyethylene plastic sheeting (poly) and duct tape.

3. Seal and tape all cracks or holes in the ceiling, walls, and floor.
4. Identify one entrance to the work area, and seal and tape all other windows and doors.
5. Seal and tape all other surfaces (e.g., columns, ledges, pipes).
6. Spray a layer of adhesive along the top of all walls and stick a layer of poly to the adhesive to cover the walls. Reinforce poly with tape around the walls.
7. Cover all inside walls in the same way, bringing poly all the way down to the floor, extending at least 16 inches onto the floor, and taping it.
8. Lay a final layer of poly over the plastic-covered floor and extend it up the walls about 2 feet depending on state regulations.

PORTABLE, HEPA-FILTERED, NEGATIVE PRESSURE UNIT

A portable, HEPA-filtered negative pressure unit consists of a cabinet with an opening at each end. One opening is for air intake and one for exhaust (Figure 7-1). A fan and a series of filters are arranged inside the cabinet between the openings. The fan draws contaminated air through the intake and filters and discharges clean air through the exhaust. The final filter must be a HEPA filter. A HEPA filter is made of paper-like material that is folded into tight pleats. The standard size HEPA filter for asbestos abatement work is approximately 24 inches high by 24 inches wide by 11 1/2 inches deep.

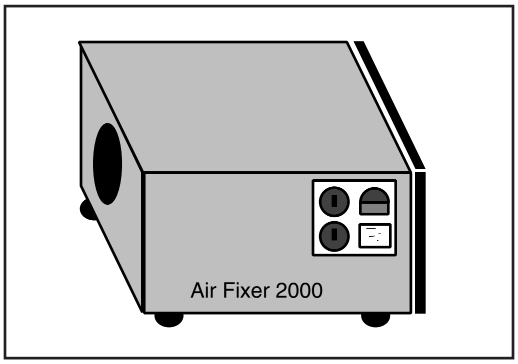

Figure 7-1. The HEPA-filtered exhaust fan filters contaminated air and discharges clean air.

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The internal mechanisms of a HEPA-filtered exhaust fan are pictured in Figure 7-2. A continuous rubber gasket is located on the filter between the filter and the filter housing to form a tight seal. The gasket material should be 1/4 inch thick and 3/4 inch wide. It should be checked for cracks and gaps when installing the filter. Contaminated air can leak through any breaks.

Each filter should be individually tested and certified by the manufacturer to have an efficiency of not less than 99.97 percent for 0.3 µm (micrometer) particles at the rated air flow. Each HEPA filtration unit can be tested on-site to ensure that it is working properly. This is called an in-place test and should be done by an independent consultant. In-place filter testing is especially recommended if HEPA units must be vented indoors.

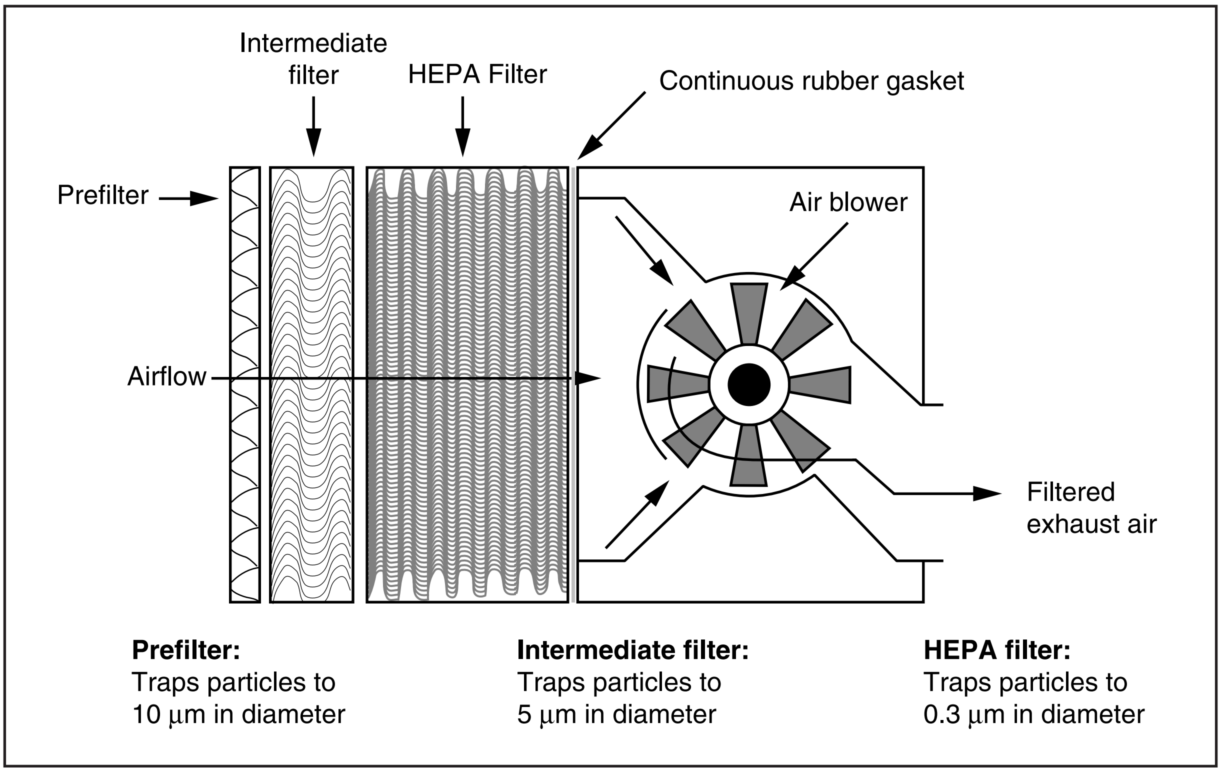


Figure 7-2. This figure shows a cross-section view of a HEPA-filtered exhaust fan.

Each filter should be marked with the following:

- Name of the manufacturer
- Serial number
- Air flow rating
- Efficiency and resistant
- Direction of air flow

Parts of the Negative Pressure Unit

Each unit should have prefilters, which lengthen the life of the expensive HEPA filter by filtering out the larger particles in the air first. Prefilters keep the HEPA filter from getting overloaded too quickly. One (minimum) or two (preferred) stages of prefilters can be used. The first-stage prefilter should be a low-efficiency type (i.e., for particles 10 µm and larger). The second-stage (or intermediate) filter should have a medium efficiency (i.e., effective for particles down to 5 µm). Intermediate filters should be installed in the intake grid of the unit and held in place with special housings or clamps.

Each unit should be equipped with a Magnehelic gauge or manometer to measure the pressure drop across the filters and to indicate when filters are loaded and need to be changed. The gauges will show an increase in pressure (increased resistance across the filters) as the filters become loaded with dust. This will affect the ability of the unit to move the necessary volume of air.

The motor, fan, fan housing, and cabinet should be grounded. The unit should have an electrical (or mechanical) lockout to prevent the fan from operating without a HEPA filter.

Setting up a Negative Pressure System

Following are the procedures for setting up a negative pressure air filter system.

Determining the Amount of Air to Exhaust for a Work Area

In the OSHA Standard 29 CFR 1926.1101, the minimum regulations for asbestos require an air exchange rate of one air change every 15 minutes or four times an hour. Areas such as large or oddly shaped rooms, or rooms that are difficult to seal may require air exchange rates that are even greater (for example, 4 to 10 times an hour).

To determine the amount of air to move to achieve four air exchanges an hour, first determine the volume (amount) of air that is in the room. The volume of a room is calculated by multiplying its length by its width by its height. Volume is written in cubic feet (ft^3).

Volume = length x width x height

Because four air changes an hour are required, the volume is multiplied by four to get the number of air changes per hour. Following is an example of how to calculate the volume of a room, the amount of air that has to be moved to obtain four air exchanges in an hour, and the number of negative air machines that are required to achieve this goal. Example:

Assume a room with the dimensions 80' x 40' x 20':

a. How many cubic feet (ft^3) are in this room?

b. For four changes in an hour, what is the total amount of air that must be exhausted in 15 minutes?

c. How much air will an 800 cubic feet per minute (cfm) HEPA unit (negative air machine) actually exhaust?

d. How many HEPA units will be needed to obtain four air changes an hour in a room of this size?

Calculation:

1. Calculate the volume (cubic feet) of the room as follows:

   80' x 40' x 20' = 64,000 ft^3

   The room has a total volume of 64,000 cubic feet or in other words, contains 64,000 ft^3 air.

2. Calculate the total amount of air that will need to be moved to change the air in the room four times. Divide 64,000 ft^3 by 15 minutes.

   64,000 ft^3 ÷15 = 4,266.67 cfm

The next step depends on the capacity of the negative air machine being used to move the air. Negative air machines come in many different sizes (capacities). The capacity of the machine is a rating by the manufacturer to describe the amount of air the machine is able to move in a minute. This is referred to as rated capacity, and is written as cubic feet per minute, or cfm. A machine that has a rated capacity of 800 cfm is capable of moving 800 cubic feet of air in one minute.

It is common for manufacturers to overrate their negative air machines. Most machines are tested under controlled laboratory conditions. It is for this reason that the ratings should not be used in field calculations. In other words, if a machine is rated at 800 cfm, it is not likely to move that much air under field conditions. Therefore, it is recommended that no more than 80 percent of the manufacturer's rated capacity should be used to calculate the actual on-the-job performance of the machine.

The negative air machine used in this example has a rated capacity of 800 cfm. To use 80 percent of the rated capacity, multiply 800 by 80 percent (.80).

800 cfm x .80 = 640 cfm

In other words, a machine that has a rated capacity 800 cfm in actuality will move air at a rate of 640 cfm. Using this information, continue with the example and calculate how much air will be moved by the negative air machine in one hour.

3. Calculations show that the 800 cfm negative air machine will actually move 640 cfm; therefore, divide the 4,266.67 cfm calculated earlier by 640 cfm.

   4,266.67 ÷640 = 6.67

4. For this space at least 6.67 negative air machines are needed. Because it is not possible to have .67 machines, round the total up to 7.

Because OSHA requires that negative air machines must run 24 hours a day for the duration of the job, backup units are necessary. The general rule is to have one backup unit for up to four machines. If there are more than four machines, add two backups. In the example, a total of nine machines is needed: seven to obtain the four air changes an hour and two for backup.

Location of Negative Pressure Unit

The negative pressure unit(s) should be located so that makeup air (air from outside the chamber) enters the work area mostly through the decontamination facility and sweeps across the work area as much as possible. This can be accomplished by putting the negative pressure unit(s) as far as possible from the work area entrance/exit or other makeup air sources.

Each unit must have electrical power (115 Volts AC). If necessary, three-wire extension cords can supply power to a unit. The cords must be in continuous lengths (without splice), in good condition, and should be no more than 100 feet long. They must not be fastened with staples, hung from nails, or suspended by wire. Extension cords should be suspended off the floor and out of the way to protect them from traffic, sharp objects, pinching, and water. Units should use separate fused outlets so that only one unit shuts down if a fuse is burned out.

Exhaust units must be vented to the outside of the building. This may involve the use of additional lengths of flexible or rigid duct connected to the air outlet and routed to the nearest outside opening. The additional resistance of this duct work will reduce air flow rate through the unit. Window panes may have to be removed temporarily.

Additional makeup air may be necessary to avoid creating too big a difference in pressure between the inside and the outside of the chamber. If the pressure difference is too great, the plastic coverings and temporary barriers may pull in.

The location of makeup air inlets should be as follows:

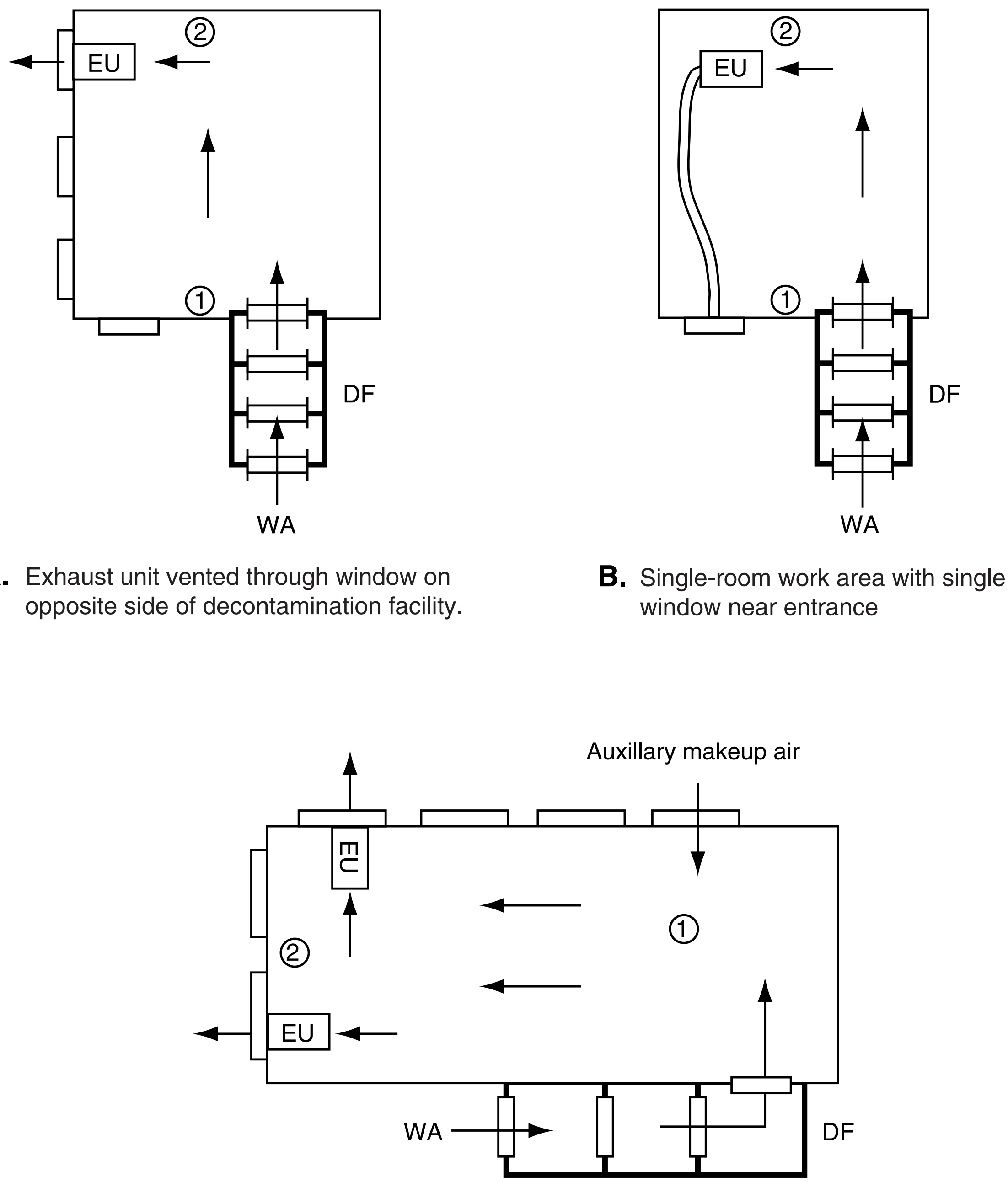
- As far away as possible from the negative pressure unit (e.g., on an opposite wall).
- Off the floor (preferably near the ceiling).
- Away from barriers that separate the work area from occupied clean areas.

Four air changes per hour may not be sufficient to get enough negative pressure, and additional HEPA units may be needed.

Figure 7-3 shows three typical examples of negative pressure system setups.

Testing the System

The negative pressure system should be tested before any ACM is wetted or removed. After the work area has been prepared, the decontamination facility set up, and the negative pressure unit(s) installed, the unit(s) should be started, one at a time. Look at the barriers and plastic sheeting. The plastic curtains of the decontamination facility may move slightly in toward the work area. The use of ventilation smoke tubes and a rubber bulb is the preferred way to visually check system performance and the direction of air flow through openings in the barrier. For example, smoke emitted on the inside of the work area flows outward. Smoke emitted in the shower room of the decontamination unit should move inward to the work area. Smoke tubes can also be used to check if air flow is moving inward at high and low levels of the work area.



A. Exhaust unit vented through window on opposite side of decontamination facility.

B. Single-room work area with single window near entrance

C. Large single-room work area with windows and auxiliary makeup air source

KEY DF = Decontamination facility
EU = Exhaust unit
WA = Worker access

Arrows = direction of air flow
Circled numbers = removal sequence

Figure 7-3. Three examples of negative pressure systems.

Use of Negative Pressure Systems During Removal Operations

The negative pressure units should be started just before beginning removal (i.e., before any ACM is disturbed). After removal has begun, the units should run continuously to maintain a constant negative pressure until the work area is decontaminated. The units must not be turned off at the end of the work shift or when removal operations temporarily stop. Air movement must be directed away from workers performing asbestos work, within the enclosure, and toward the HEPA filtration negative air machine.

Workers should start removing the asbestos material at a location farthest from the negative pressure units and work toward them. If an electric power failure occurs, removal must stop immediately and should not start again until power is restored and negative pressure units are operating again. Spare units should be available to make sure continuous operation is possible. The number of spare units depends on the size of the job.

Changing the Air Filters

When the pressure drops across the filters (as shown by the Magnehelic gauge or manometer on the unit) exceeds 1.0 inch of H_2O above the pressure of the system with new filters, the prefilter should be replaced first. Because the suction holds the prefilter in place, carefully remove it by curling or folding the sides in. Any dust dislodged from the prefilter during removal will be collected on the intermediate filter. The used prefilter should be placed inside a 6-mil plastic bag, sealed, labeled, and disposed of as asbestos waste. A new prefilter is then placed on the intake grill. Prefilters can be purchased as individual pre-cut panels or in a roll of specified width that must be cut to size. If the pressure drop still exceeds 1.0 inch of H_2O above the pressure of the system with new filters (after the prefilter has been replaced), the intermediate filter is replaced. With the unit operating, the prefilter should be removed, the intake grill or filter access opened, and the intermediate filter removed. Any dust dislodged from the intermediate filter during removal will be collected on the HEPA filter. The used intermediate filter should be placed in a sealed, labeled 6-mil plastic bag, and disposed of as asbestos waste. A new replacement filter is then installed and the grill or access closed.

The HEPA filter should be replaced if prefilter and intermediate filter replacement does not restore the pressure drop across the filters to an acceptable resistance reading or if the HEPA filter becomes damaged (HEPA filters will fail if they absorb too much moisture). The exhaust unit is shut off and disconnected from the power source to replace the HEPA filter, which requires removing the HEPA filter from the unit. The used HEPA filter should be placed in a sealed, labeled, 6-mil plastic bag and disposed of as asbestos waste.

SECTION 7 - ASSIGNMENT SHEET

1. List the two most important goals for a negative pressure air system.

2. List the four benefits of a negative pressure air system.

3. Describe how a negative pressure air filter system creates a negative pressure, and how this reduces the concentration of airborne asbestos within the work area.

4. List the eight guidelines for constructing a negative pressure enclosure.

5. Describe how a portable HEPA-filtered negative pressure unit functions.

6. Name the three filters that are part of the HEPA-filtered exhaust unit.

7. Explain what an air change is and how many are recommended every hour.

8. Describe where the negative pressure unit should be located within a work area, and give the reason for the placement of the unit at this location.

9. Describe how a negative pressure system is tested.

10. Describe how and when the filters of the negative pressure unit are changed.

Section
8

ASBESTOS ABATEMENT WORKER REFRESHER

Title

PREPARING THE WORK AREA AND DECONTAMINATION UNIT

TRAINEE OBJECTIVES

After completing Section 8, you will be able to:

1. Define the following acronyms and terms:

   Clean room
   Equipment room
   HVAC
   Shower room
   Waste load-out area

2. Give four examples of why preplanning asbestos abatement operations is essential.

3. List the 12 steps in preparing the work area.

4. Explain what a decontamination unit is.

5. List the elements of the decontamination chamber and explain the function of each.

6. List the materials and equipment needed for preparing the work area and setting up a decontamination unit. Describe how these are to be used.

INTRODUCTION

The information in this section is based on the *Procedures and Practices for Asbestos Abatement Projects Manual* developed by Georgia Tech Research Institute and by Tufts University with U.S. Environmental Protection Agency (*EPA*) funding.

PREPARING THE WORK AREA

Preparing the work area will be different for each project, but there are general guidelines that should be followed for all projects. These guidelines can be modified to address specific problems encountered during asbestos abatement or changed to meet state or local requirements.

Steps in Preparing the Work Area

The following twelve steps should be followed when preparing the work area.

Step 1 - Conduct a Walk-through of the Work Area

The contractor, building owner, and architect should conduct a walk-through survey to inventory and photograph any existing damage.

Step 2 - Post Warning Signs

Warning signs should be placed at each entrance to the work area. Signs must be posted at stairways and elevators warning of the dangers; these areas must also be sealed off.

Step 3 - Shut Down Heating, Ventilating, and Air Conditioning Systems

The heating, ventilating, and air conditioning (*HVAC*) systems supplying the work area should be shut down and isolated to prevent the asbestos dust from being blown throughout the building.

HVAC filters, which may be contaminated with asbestos dust, should be removed and disposed of in the same manner as the other asbestos-containing materials (*ACM*s).

Step 4 - Clean and Remove Furniture and Nonstationary Items from the Work Area

Workers wearing half-mask high efficiency filter cartridge respirators and disposable clothing should remove all nonstationary items that can feasibly be taken out of the work area. Before storing the items outside the work area, they should be cleaned with a high efficiency particulate air (*HEPA*) filtered vacuum and/or wet-wiped to remove any asbestos-containing dust.

Step 5 - Seal Stationary Items with 6-mil Poly

Items not being removed from the work area, such as large pieces of machinery, blackboards, pencil sharpeners, water fountains, toilets, etc., should be wet-wiped or HEPA-vacuumed, wrapped in place with poly, and sealed with duct tape.

Step 6 - Tape and Seal Windows and Doors with Poly

The edges of all the windows should be sealed with 3 inch wide high quality duct tape. After the edges have been taped, the windows should be covered and sealed with poly and duct tape. Whenever possible, completely cover the windows and doors with the plastic barrier. (Figure 8-1).

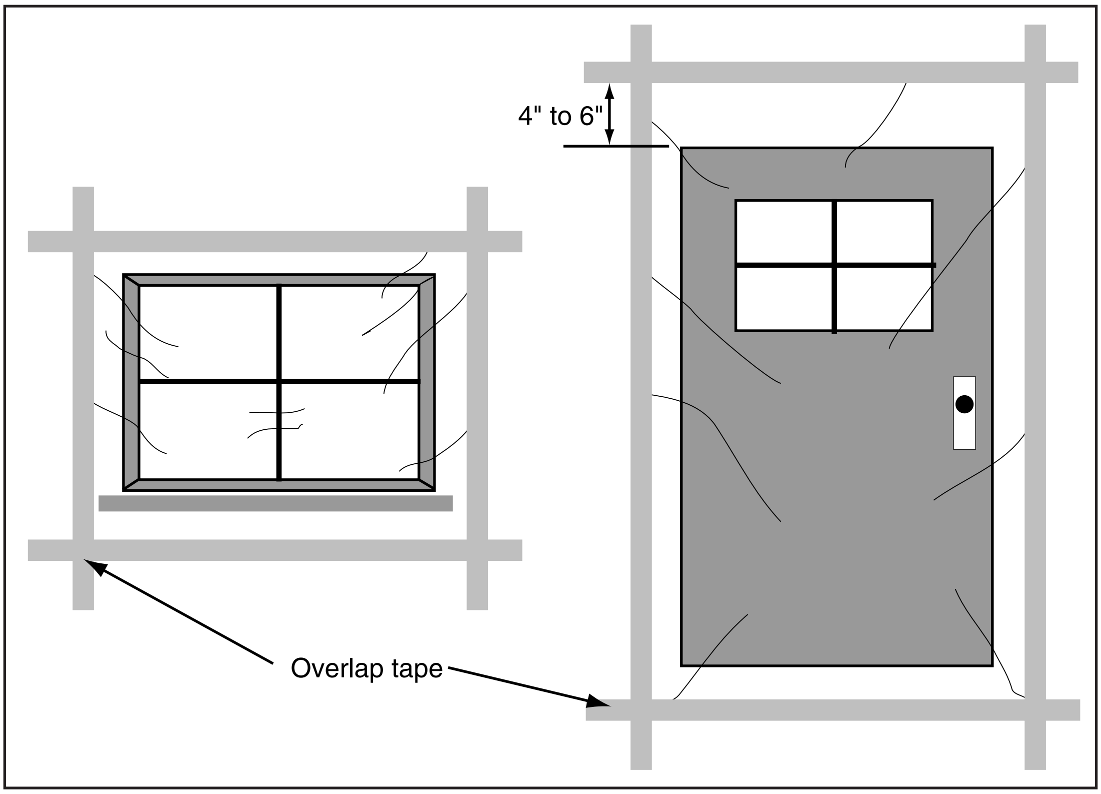


Figure 8-1. Windows and doors are sealed with 6-inch mil poly and duct tape.

Step 7 - Cover the Floor with Poly

Poly sheets must be used to cover the floor in the work area. Several sheets may be seamed together with spray adhesive and duct tape. Figure 8-2 illustrates the proper method of seaming poly together using the double duct tape seam method.

After joining the sheets of poly together, the floor covering should be cut to the proper dimensions, allowing the poly to extend 24 inches up the wall all the way around the room. The poly should be flush with the walls at each corner to prevent damage from foot traffic.

When the first layer of poly is in place, a second layer should be installed with the seams of the first and second layers offset. The second layer of poly should extend a few inches above the first layer on the wall and be secured with 3-inch duct tape.

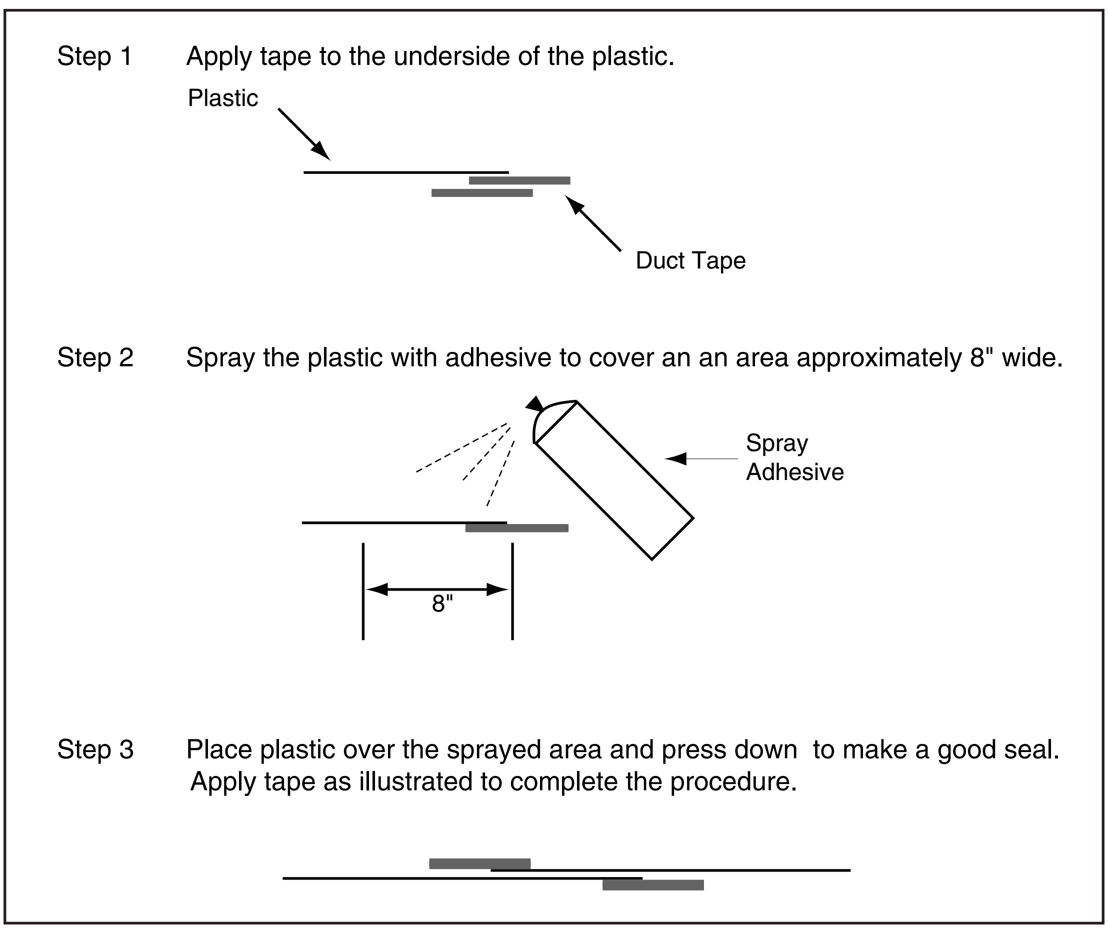


Figure 8-2. This figure shows the procedure for making double duct tape seams.

Step 8 - Cover the Walls with Poly

After the floors and stationary objects have been covered with poly, two layers of poly are used to cover the walls. However, state regulations or job specifications, may require the use of special poly that is fire retardant, opaque, or reinforced (Figure 8-3).

The sheets of poly should be hung from the top of the wall a few inches below the asbestos material, and should be long enough to overlap the floor sheets by 24 inches. The vertical sheets should be overlapped and seam-sealed with adhesive and duct tape.

After completion of the taping and covering of the internal fixtures, plastic is then placed over the walls and taped along the top and bottom of the walls. A good preventative measure is to spray this tape with a water repellent substance to prevent separation when sprayed with amended water.

The sheet should be hung using a combination of nails and furring strips (small wood blocks), or adhesive and staples, and sealed with 4 inch duct tape. Duct tape alone will not support the weight of the poly after exposure to the high humidity that often occurs inside the work area. Nails may cause some minor damage to the interior finish. However, it is usually more time efficient to tough up the nail holes than to repeatedly repair fallen barriers. To provide maximum protection to floor coverings if required, it is recommended that plastic be fastened a minimum of 24 inches up the wall.

Step 9 - Locate and Secure the Electrical System to Prevent Shock Hazards

Amended water is used to soak asbestos-containing sprayed-on material before removal. This creates a humid environment, with damp-to-very wet floors. The electrical supply to the work area should be deenergized and locked out before removal operations begin in order to eliminate the potential for a shock hazard.

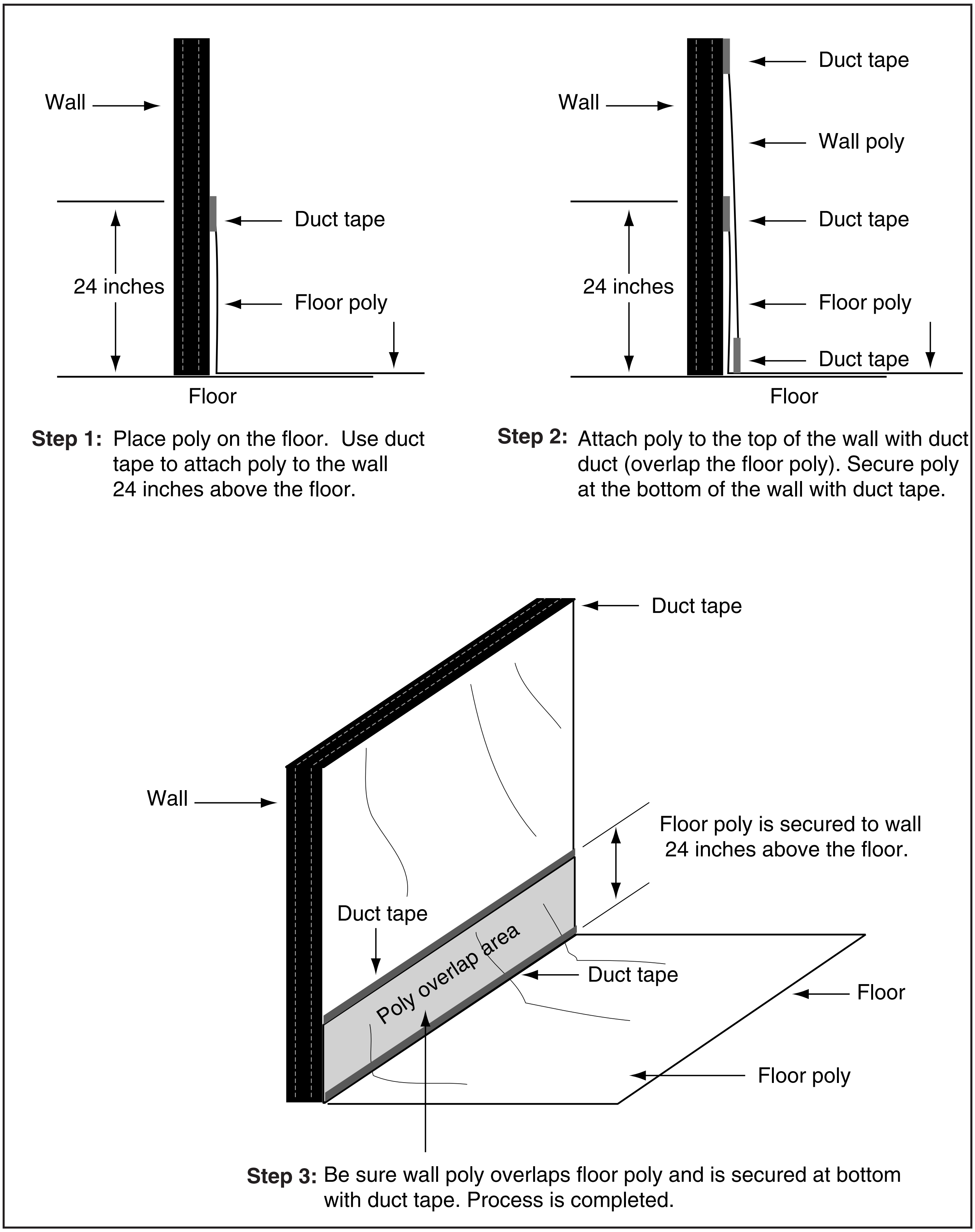


Figure 8-3. Follow these procedures to cover the floors and walls with poly.

These are the steps to follow before removal begins:

- Identify and deenergize electrical circuits in the work area.
- Lock the breaker box after the system has been shut down and place a warning tag on the box.
- Make provisions for supplying the work area with electricity from outside the work area that is equipped with a ground fault circuit interrupt (GFCI) system.
- If the electrical supply cannot be disconnected, energized parts must be insulated or guarded from employee contact and any other conductive object.

Walls

8

Step 10 - Remove/ Cover Light Fixtures

Light fixtures may have to be removed or detached and suspended to gain access to ACM. (Bailing wire works well.) Before beginning this task, the electrical supply must be shut off. Light fixtures should be wet-wiped before they are removed from the area. If it is not feasible to remove the light fixtures, they should be wet-wiped, then draped with plastic or completely enclosed.

Step 11 - Shut Down Water Systems

Water pipes should be shut down, if possible, to prevent accidental discharge into the work area or behind the poly covering the walls or floors.

Step 12 - Secure the Work Area

All entrances and exits should be secured when removal operations are not in progress. Provisions must also be made to secure the decontamination station entrance when no one is on the job site. Security guards may be a reasonable precaution, depending on the nature of the project.

When the work area is occupied, padlocks must be removed to permit emergency escape routes. Arrows should be taped on the polyethylene-covered wall to indicate the location of exits.

SETTING UP A DECONTAMINATION UNIT

The decontamination unit is designed to allow passage to and from the work area during removal operations, with minimal leakage of asbestos-containing dust outside the work area. A typical unit consists of a clean room, a shower room and an equipment room, separated by *air locks*. The air locks are formed by overlapping two sheets of poly at the exit of one room, and two sheets at the entrance to the next room, with 3 feet of space between the barriers (see Figure 8-4). There are various methods for constructing air locks, including a hatch type construction and a slit and cover design. Materials used to construct a typical unit include:

- 2 x 4-inch lumber for the frame
- 1/4- to 1/2-inch plywood or 6-mil poly for the walls
- Duct tape
- Staples and nails

The floor should be covered with three layers of poly. The decontamination unit can be built in sections to allow for disassembly and re-use at another area of the building. The design of the decontamination station will vary with each project depending on the size of the crew and the physical layout of the facility.

Clean Room

No asbestos-contaminated items should enter the clean room. Workers use this area to suit up, store street clothes, don respiratory protection, and to dress in clean clothes after showering. Ideally this room should be furnished with benches, lockers for clothes and valuables, and nails for hanging respirators.

Shower Room

Workers pass through the shower room on their way to the removal area and use the showers on their way out after leaving contaminated clothing in the equipment room. Although most job specifications require only a single shower head, installation of multiple showers may be time and cost effective if the work crew is large.

Shower waste water should be collected and treated as ACM or filtered before disposal into the sanitary sewer. State and local requirements on methods of shower waste water disposal vary. For example, Alabama, Georgia, Maryland, and New Jersey each have written specifications for handling shower waste water.

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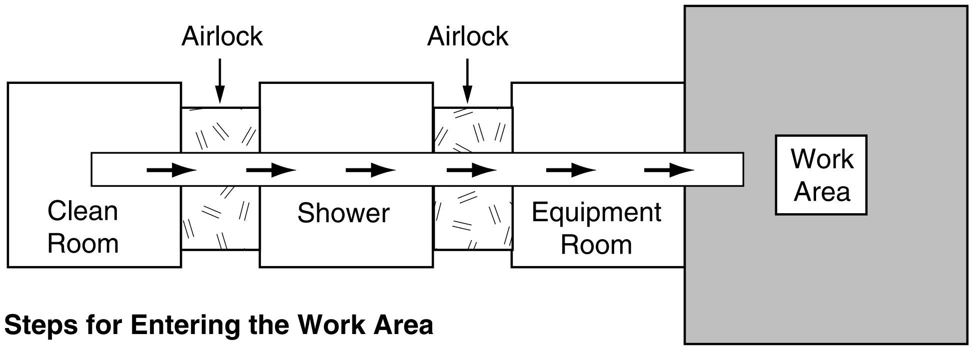
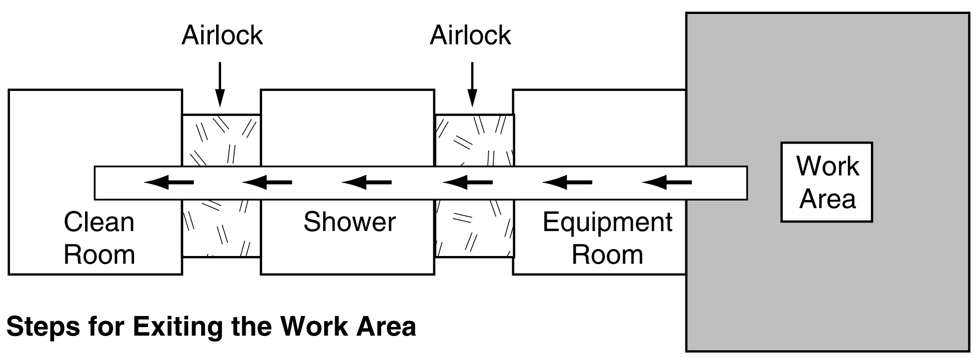


Steps for Entering the Work Area

1. Enter clean room.
2. Remove clothing and place in locker.
3. Put on clean coveralls.
4. Put on separate disposable foot coverings if they are used.
5. Tape around ankles and wrists, as needed.
6. Inspect and don respirator.
7. Put hood on over respirator straps.
8. Proceed to equipment room.
9. Put on any additional clothing or protective equipment once in the equipment room,
10. Collect tools and proceed to work area.



Steps for Exiting the Work Area

1. Brush off gross contamination, then enter equipment room.
2. Remove all clothing except respirator.
3. Place disposable clothing in bag or bin.
4. Store any contaminated articles.
5. Proceed to shower.
6. Once in shower, wet respirator without removing.
7. Remove respirator.
8. Thoroughly wash body and hair.
9. Clean and dry respirator.
10. Step into clean room, dry off, and redress in clean coveralls or street clothes.

Figure 8-4. Steps for entering and exiting the work area.

Equipment Room

The equipment room is a contaminated area where equipment, boots or shoes, hard hats, goggles, and any additional contaminated work clothes are stored. Workers place disposable clothing, such as coveralls, booties, and hoods, in bins before leaving this area for the shower room. Respirators are worn until workers enter the shower and thoroughly soak them with water. The equipment room may require clean up several times daily to prevent ACM from being tracked into the shower and clean rooms.

Waste Load-Out Area

The waste load-out area is separate from the decontamination unit. It is used as a short-term storage area for bagged waste and as a port for transferring waste to the truck. An enclosure can be constructed to form an air lock between the exit of the load-out area and an enclosed truck (See Figure 8-5).

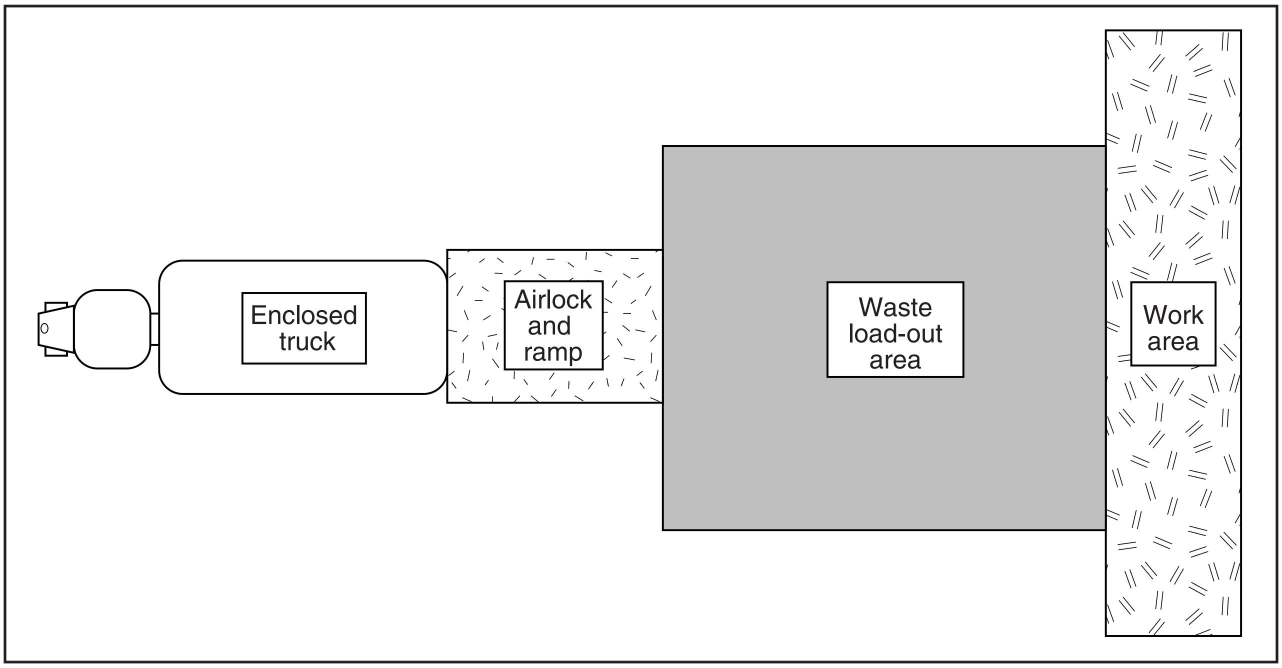


Figure 8-5. This illustration depicts a typical waste load-out area.

The outside of the waste containers should be free of all contaminated material before removal from the work area. Gross contamination should be wiped or scraped off containers before they are placed in the load-out area. Any remaining contamination should be removed by wet-wiping, or the bagged material can be placed in a second clean bag. To save cleanup time, fiber drums can be covered with an outside bag of polyethylene before they are taken into the work area. The polyethylene bag can then be removed before taking the drum into the load-out area.

OSHA DECONTAMINATION REQUIREMENTS

Under the Asbestos Standard for Construction, 29 CFR 1926.1101, OSHA has established requirements for proper decontamination procedures in all four classifications of asbestos work. Decontamination procedures differ because each classification exposes workers to different levels of asbestos contamination. The following is a summary of the requirements for decontamination procedures in each of the four work classifications.

Class I Decontamination Requirements (Large Scale Work)

Workers who are performing Class I asbestos work involving over 25 linear feet or 10 square feet (large scale work) of *thermal system insulation* (*TSI*), or *surface material* (*SM*) ACM, or presumed ACM (*PACM*), the employer must establish a decontamination area. The following requirements for the decontamination area must be met:

- The decontamination area must be adjacent and connected to the regulated area.
- The decontamination area must consist of an equipment room, shower area, and a clean room arranged in a series.
- Showers must be adjacent to both the equipment room and clean room, unless the employer can demonstrate that this is not feasible.

If the employer can demonstrate that it is not feasible to locate the shower between the equipment room and clean room, or if the work is performed outdoors, the employer must ensure that workers do the following:

- Remove asbestos contamination from their work suits in the equipment room using a HEPA vacuum before proceeding to a shower that is not adjacent to the work area.

- Remove their contaminated work suits in the equipment room, don clean work suits, and proceed to a shower that is not adjacent to the work area.

Class I (Small Scale Work), II, and III Decontamination Requirements

For employees in Class I (small scale work involving less than 25 linear or 10 square feet of TSI, SM ACM, or PACM), and for Class II and III asbestos work operations where exposures exceed the *permissible exposure limit* (*PEL*) or where there is no *negative exposure assessment* (*NEA*) produced, before the operation the employer must:

- Establish an equipment room or area that is adjacent to the regulated area for the decontamination of workers and equipment. The floor and horizontal working surfaces must be covered by an impermeable drop cloth.

- Ensure that the area is of sufficient size to accommodate cleaning of equipment and removing *personal protection equipment* (*PPE*) without spreading contamination beyond the area (as determined by visible accumulations).

- Ensure that work clothing is cleaned with a HEPA vacuum before it is removed.

- Ensure that the outside surfaces of all equipment and containers filled with ACM are cleaned before removing them from the equipment room.

Class IV Decontamination Requirements

Employers must ensure that workers performing Class IV work within a regulated area comply with the hygiene practices required of workers performing work of a higher classification within that regulated area. Otherwise, workers cleaning up debris and material that is TSI, SM ACM, or identified as PACM must be provided decontamination facilities just like those required for Class I (small scale work), II, and III asbestos work.

Note: The requirements for Class IV decontamination are contradictory to the definition of Class IV work. A close study of the OSHA standard indicates that it is possible for a Class IV worker to enter a Class I regulated area and perform clean up activities. The very definition of Class IV work involves incidental disturbance of asbestos while performing routine maintenance activities, and not the cleanup of large scale Class I asbestos work debris. This discrepancy is justified because the training for Class IV workers is not adequate enough for them to be working in a Class I environment.

MATERIALS AND EQUIPMENT LIST

Table 8-1 is a materials and equipment list for preparing a work area and setting up a decontamination unit for performing asbestos abatement work.

Table 8-1. Materials and equipment list for preparing a work area and setting up a decontamination unit.

MATERIAL AND EQUIPMENT	DESCRIPTION			
Polyethylene sheeting material	**Use:**	Seal off work areas and items in work areas; protect surfaces in the work area (other than those being altered); construct decontamination and enclosure systems. Some localities require fire-retardant poly.		
	Types:	4-mil thickness 6-mil thickness	12' x 100' rolls 20' x 100' rolls	20 lbs 60 lbs
Duct tape	**Use:**	Seam poly sheets together; form airtight seal between poly and wall; provide some support for vertical sheets.		
Adhesive spray	**Use:**	Seal seams, provide additional support to vertical sheet.		
Furring strips (cut into blocks)	**Use:**	Support vertical sheets of poly.		
Nails	**Use:**	Attach furring strips to top edge of poly and wall; construct the frame of the decontamination unit.		
Staples and staple gun	**Use:**	Attach poly to wood frame.		
Retractable razor knives	**Use:**	Slice poly and tape.		
Warning signs	**Use:**	Post at entrances to building and decontamination unit.		
Vacuum cleaner with HEPA filter	**Use:**	Clean nonstationary items before removing them from the work area.		
Ladders and/or scaffolding				
Carpentry tools (such as hammers and saws)				
Prefab shower stalls or materials for shower construction				

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SECTION 8 - ASSIGNMENT SHEET

1. Define the following acronyms and terms:

   Clean room ______________________________

   ____

   Equipment room ______________________________

   ____

   HVAC ______________________________

   ____

   Shower room ______________________________

   ____

   Waste load-out area ______________________________

   ____

2. Give four examples of why preplanning asbestos abatement operations is essential.

   ____

   ____

   ____

   ____

   ____

   ____

3. List the 12 steps in preparing the work area.

4. Explain what a decontamination unit is.

5. List the elements of the decontamination chamber, and explain the function of each.

6. List the materials and equipment needed for preparing the work area and setting up a decontamination unit. Describe how they are to be used.

ASBESTOS ABATEMENT WORKER REFRESHER MANUAL

Section
9

Title
ASBESTOS ABATEMENT TECHNIQUES

TRAINEE OBJECTIVES

After completing Section 9, you will be able to:

1. Define the following acronyms or terms:

   Amended water
   Encapsulation
   Enclosure
   Glove bag
   HEPA vacuum
   NESHAPS

2. Describe the difference between bridging and penetrating sealants.

3. List three advantages and seven disadvantages of encapsulation.

4. List three advantages and seven disadvantages of enclosure.

5. List ten tools commonly used with a glove bag.

6. Describe the two stages of asbestos abatement.

7. List the nineteen steps of the final cleanup.

INTRODUCTION

In this section, various asbestos abatement techniques are presented. Abatement techniques include encapsulating the a*sbestos-containing material* (*ACM*), enclosing the ACM within specially constructed barriers, glove bagging techniques, and wet removal techniques. Other important considerations during abatement, including cleaning up the work area, preparing waste for disposal, waste load-out procedures, and transporting the ACM to a disposal site will also be discussed.

ENCAPSULATION

Encapsulation involves spraying or painting the ACM with a bonding agent called a sealant. There are two kinds of sealants:

1. Bridging sealants
2. Penetrating sealants

A *bridging sealant* forms a tough coating on the surface of the material. A *penetrating sealant* soaks through the ACM and binds together the asbestos fibers and other material components. Ideally, the penetrating type of sealant should penetrate the entire depth of the insulation; this will also help bond the material to the *substrate* (the surface or material to which the asbestos or ACM is attached). The sealant should be flexible, flame-retardant, non-toxic, and resistant to impact damage and deterioration over time, and not give off toxic fumes when burned. Both types of sealants may interfere with insulating and acoustical properties.

The purpose of encapsulation is to prevent fiber release from the ACM. During the encapsulation process, the fiber counts may be as high as other abatement processes. Proper respiratory protection must be worn to protect against both the asbestos fibers and the fumes associated with the specific encapsulant.

Materials Needed for Encapsulation

Materials needed for encapsulation include the following:

- Airless sprayers
- Appropriate encapsulant for the job
- Personal protective equipment (*PPE*)

Bridging and Penetrating Sealants

Penetrating sealants usually have a lower solid content than bridging sealants. Bridging sealants are almost always pigmented for aesthetic purposes. Penetrating sealants do not usually contain pigment because its presence would interfere with penetration.

For friable ACM on irregular or pointed surfaces, such as pipes and ducts, or where the insulation may be hit, a bridging sealant may be preferable to a penetrating sealant. Unless a penetrating sealant penetrates all the way to the substrate, it will not contribute anything to substrate bonding. Most penetrating sealants do not penetrate more than an inch into spray-applied asbestos material. They are unlikely to bind thicker ACMs to the substrate.

Penetrating sealants tend to impair the thermal insulating properties of ACMs more than bridging sealants. ACM retains heat well because of the dead air spaces in the material. While a good penetrating sealant will not completely fill all these gaps, any penetrating sealant will reduce the amount of dead air space and improve point-to-point contact in the ACM. Where thermal insulating properties of the material are important, a bridging sealant is likely to be preferable.

Preparing the Work Area

Preparing a work area for asbestos abatement requires a worker to:

- Contain the work area with polyethylene sheeting
- Set up a decontamination facility

The "Preparing the Work Area, and Setting Up the Decontamination Unit" section of this manual contains additional information.

Pretest Application and Testing

Pretest sealant application and testing consists of the following two steps:

1. Apply sealant to a small test area and observe how well it penetrates (for penetrating sealant) or observe adhesion (for bridging sealant).

2. Test ACM with a hanging weight to determine whether it has enough strength to support the added weight of the encapsulant.

Note: The Environmental Protection Agency (*EPA*) evaluated more than 100 sealants, using five criteria:

1. Impact resistance
2. Flame spread
3. Smoke generation
4. Toxic gas release during combustion
5. Adhesive or cohesive strength

Basic Steps for Encapsulation Operations

Following are the basic steps for encapsulation operations:

1. Apply a light (mist) coat
2. Apply remaining applications from different directions
3. Clean up the work area - refer to "Cleaning Up the Work Area" in this section

Worker Health and Safety Precautions

Many of the precautions required for encapsulation are the same as those for removal.

- Do **no**t use a solvent-based material as a spray-applied encapsulant because of possible toxicity or fire hazard.

- Refer to the following sections in this manual for additional precautions:

  – "Personal Protective Equipment"
  – "Preparing the Work Area, and Setting Up the Decontamination Unit"
  – "Site Safety"
  – "Air Monitoring"

Advantages and Disadvantages of Encapsulation

The three advantages of encapsulation include:

1. Reduced asbestos fiber release from material
2. Initial costs may be lower than for removal
3. Does not require replacement of material

The seven disadvantages of encapsulation include:

1. Asbestos source remains and must be removed later.
2. If material is not in good condition, sealant may cause material to peel and crack.
3. Periodic reinspection is required to check for damage or deterioration.
4. Repair of damaged or deteriorating encapsulated surface is required.
5. An encapsulated surface is difficult to remove and may require dry techniques for eventual removal.
6. Long-term costs may be higher than for removal.
7. Workers will require training for maintenance.

When to Use Encapsulation

Encapsulation should be used when:

- Material is *granular* and *cementitious*
- Material still retains bonding integrity
- Physical damage to material is unlikely to occur
- Material is inaccessible to untrained workers
- Material is spray-applied (penetrating sealant is generally more effective than bridging)
- After removal of ACM, when the substrate is porous

Note: If air cell (corrugated asbestos paper) pipe insulation is to be encapsulated, all joints, seams, ends, and hangers must first be closed.

When Not to Use Encapsulation

Encapsulation should **not** be used when the material:

- Is fibrous and fluffy
- Does not adhere well to substrate
- Is damaged or deteriorating
- Is likely to be mechanically damaged
- Has been damaged by water or is likely to be damaged

ENCLOSURE

The information in this section is based on the *Procedures and Practices for Asbestos Abatement Project Manuals* developed by Georgia Tech Research Institute and Tufts University with Environmental Protection Agency (*EPA*) funding.

Enclosure involves the construction of airtight walls, ceilings, or barriers around the ACM. The purpose of constructing an enclosure is to isolate the ACM from the rest of the building and the people in the building. Enclosures should be constructed with impact-resistant material and assembled to be airtight. Types of material used to construct enclosures are polyvinyl chloride (*PVC*), aluminum, gypsum board, rewettable glass cloth, fiberglass, and steel. Suspended ceilings with lay-in panels are not considered effective for asbestos enclosure.

Advantages of Enclosure

The three advantages of enclosure include:

1. Reduces exposures in area outside enclosure
2. Initial costs may be lower than for removal unless utilities need relocating or major changes
3. Usually does not require replacement of material

Disadvantages of Enclosure

Eight disadvantages of enclosure include:

1. Asbestos source remains and must be removed eventually.

2. Fiber release continues behind enclosure.

3. Special operations program is required to control access to enclosure for maintenance and renovation.

4. Periodic reinspection is required to check for damage.

5. Repair of damaged enclosure is necessary.

6. Fibers are released during construction of enclosure.

7. Long-term costs could be higher than for removal.

8. Workers will require training for maintenance.

When to Use Enclosure

Enclosure should be used when:

- ACM is located in a small area (e.g. a column)
- Disturbance or entry into enclosed area is unlikely

Note: Enclosure material should be of a similar fire rating as required by the applicable building codes.

When Not to Use Enclosure

Enclosure should not be used when:

- Material is damaged or deteriorating and fiber release is high.

- Material has been or will be damaged by water.

- Damage or entry into enclosure is likely.

- In areas where the enclosure would cause an obstruction, such as under a low ceiling.

GLOVE BAG PROCEDURES

The information in this section is based on the *Asbestos Policy and Procedure Manual*, Division of Occupational Hygiene, Massachusetts Department of Labor and Industries.

Glove bags are 6–12 mil polyethylene bags fitted with long sleeve gloves, a tool pouch, and a 2-inch opening used for water application. Glove bags are used primarily for removal of asbestos around pipes, but also have other specific uses. The size, quality, style, and cost vary depending on the manufacturer. In addition to glove bags, several other tools and materials are commonly required to perform the project successfully. The materials listed in this subsection are readily available from most asbestos abatement contractor suppliers and local hardware stores. Remember, the glove bag does not provide perfect containment and may not be allowed in all areas.

Work Practice for Glove Bagging

Glove bagging is a common method of abatement that is used on most job sites. Even though this is very common, there are still many work practices that must be adhered to during these operations.

- Before beginning the operation, any loose and friable asbestos adjacent to the glove bag must be wrapped and sealed with two layers of 6-mil plastic or otherwise rendered intact.
- Each glove bag must be installed so it completely covers the structure where the activity is taking place.
- The glove bag must be tested for leakage by using a smoke test.
- Glove bags may be used only once and cannot be moved to another area for continued abatement.
- In areas where temperatures exceed 150° F glove bags may not be used.
- Where systems use an attached waste bag, it must be connected to the collection bag using a hose or other material, which must withstand pressure of ACM waste and water without loosing its integrity.
- A sliding valve or other device must separate the waste bag from the hose to ensure no exposure when the waste bag is disconnected.
- At least two persons must perform Class I glove bag removals.
- After completion of the operations, the glove bag must be collapsed by removing the air from within the bag using a HEPA vacuum.

Materials for Glove Bagging

The following are materials used with glove bagging. Not all materials are used on every job.

1. Glove bag (seamless at the bottom).
2. Pump-up garden sprayer (2- to 3-gallon) with a hose at least 6 feet long.
3. *Surfactant* - 50 percent polyoxyethylene ester and 50 percent polyoxyethylene ether, or equivalent.
4. Duct tape - 3 inches wide.
5. Prelabeled polyethylene asbestos disposal bags, 6-mils thick.
6. 16-inch bone saw - flexible saw with a serrated heavy gauge wire and ring-type handles (Figure 9-1).

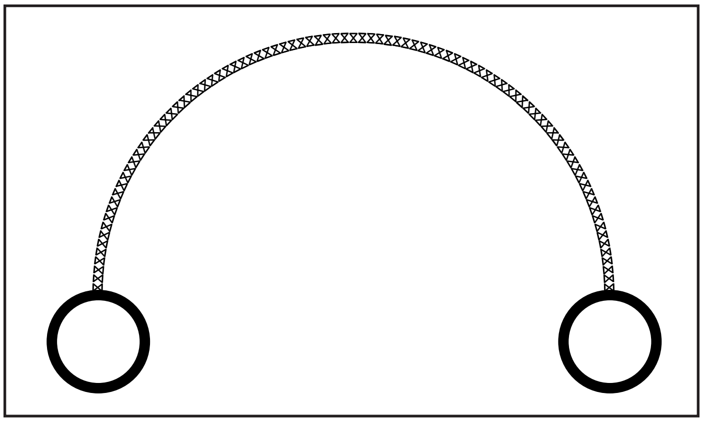

Figure 9-1. A bone saw has a serrated cutting wire.

7. Utility knife with retractable blade.
8. Scrub brush with nylon bristles.
9. Several rags.
10. Rewettable fiberglass cloth - a plaster-impregnated fiberglass webbing available through many insulation suppliers.
11. Zip-lock™ plastic bag (approximately 8 x 10 inches).
12. Hand stapler and staples.

13. Polyethylene plastic 4- or 6-mils thick.
14. Asbestos warning signs and labels.
15. Rope.
16. Ventilation smoke tubes.
17. Aspirator bulb with 6 inches of tubing.
18. HEPA vacuum cleaner - wiring must include a ground plug or ground fault circuit interrupter.
19. Water bucket.
20. Rubber dustpan or shovel.
21. Ice scraper, garden trowel, or putty knife.
22. Spray bottle - mister.
23. String.
24. Scissors.
25. Dual cartridge, half-face respirator (with HEPA cartridges if fiber concentration allows their use).
26. Disposable suits, booties, and hood or head covering.
27. Encapsulant.

Prework Procedures

It is best to have two people present throughout the procedure and it is required for Class I removal. One person performs the removal, while the other one wets the material. Prework procedures include the following:

- Check the temperature of the pipes. **Never perform a glove bag removal on hot pipes (over 150° F.)** High temperatures can cause the bag or gloves to melt over your hands and arms. If pipes are hot, use high temperature glove bags. If the pipe temperature is over 150°F, the heat source to this pipe must be temporarily shut off, and the pipe allowed to cool before work begins.

- Gather all necessary materials and supplies.

- Isolate the work area. Post asbestos warning signs around the perimeter so that other people will not enter the area.

- Mix surfactant with water and place in the garden sprayer and mister. **Note:** See manufacturer's guidelines for mixing ratio. Mix to the specifications.

- Use duct tape to tape 6-mil polyethylene sheeting to the floor and partially up the walls in the immediate work area.

- If possible shut down the heating, ventilation, and air conditioning (*HVAC*) system serving the area. Alternatively seal off all vents with polyethylene.

- Review employer's emergency procedures for glove bag.

- Cut two donut-shaped pieces of re-wettable fiberglass cloth (Figure 9-2). The inner diameter should be 1/2 inch smaller than the diameter of the pipe beneath the insulation. The outer diameter of the donut should be about 3 inches larger than the diameter of the pipe with the insulation. Cut a slit through one side of the donut. Place both pieces in the zip-lock bag.

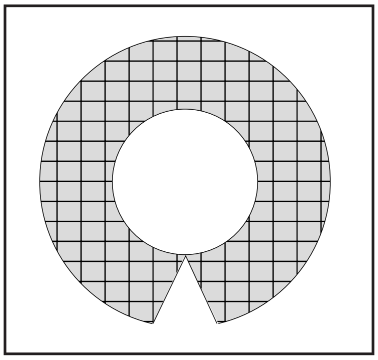

Figure 9-2. Cut two pieces of fiberglass cloth.

Worker Protection

There are procedures to follow that help ensure worker protection when working with glove bags, including:

- Put on respirator and check fit. (Refer to the PPE section of this manual
- Put on disposable full body suit, head covering, and booties. Remember, the head covering goes over respirator straps.

Setting Up the Glove Bag

Procedures in this subsection are followed to set up the glove bag. The final configuration of a glove bag is shown in Figure 9-3.

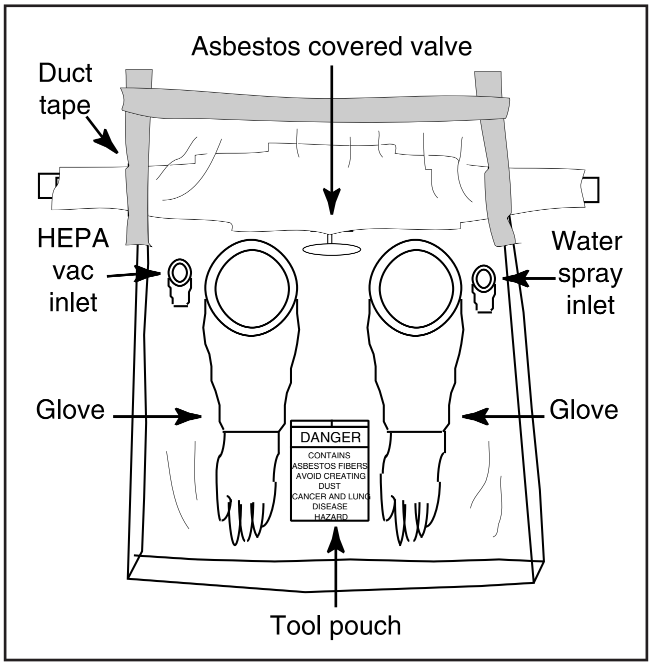

Figure 9-3. A typical glove bag arrangement is shown.

- Check the pipe where the work will be performed. If there are areas of damaged pipe covering around the section to be removed, patch with rewettable fiberglass cloth. A common error when doing glove bag removals is forgetting that loose pipe lagging several feet or several yards away may be jarred loose by the activity, thus generating airborne fibers.
- Place two layers of duct tape around the pipe at each end where the glove bag will be attached. (Determine this by holding the glove bag up to the pipe to see the

length.) This provides a good surface on which to seal the ends of the glove bag. Do not tape directly to the pipe. Either reverse the tape or cover it with plastic first (Figure 9-4).

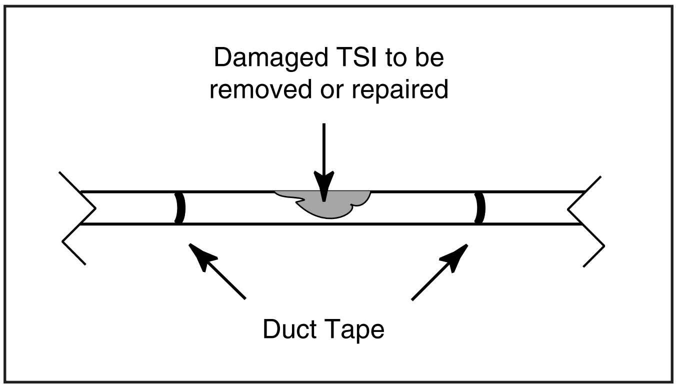

Figure 9-4. The pipe is prepared for glove bag attachment.

- With scissors, slit the top of the glove bag open, if necessary, and cut down the side seams approximately 8 inches longer than the pipe diameter.

  Note: For brands with zipper tops and straps, this step may not be necessary.

- Run duct tape horizontally along one of the top seams for reinforcement and to seal the bag.

- Place the following tools into the pouch inside the glove bag:

  - Bone saw
  - Utility knife (closed)
  - Nylon scrub brush and rags
  - Rewettable fiberglass cloth inside a zip-lock bag

  If necessary, use wire cutters or tin snips to cut wire hangers or aluminum jackets.

  Make sure all the necessary tools are in the bag before proceeding further.

9

- Place the glove bag around the section of pipe to be worked on and staple the top together through the reinforcing duct tape. Staple at 1 inch intervals.

- Fold the stapled section over and tape it horizontally to the glove bag with duct tape.

  Note: It will seal best if a few shorter pieces of tape are used rather than one long strip.

- Lift the glove bag up so that the bottom of the pipe is flush against the end of the side slit on the glove bag. Duct tape the ends of the glove bag to itself and to the strip of duct tape previously placed on the pipe covering.

  Note: There should be adequate room at the top of the glove bag to reach over the top of the pipe. If the glove bag is not lifted up and taped, there will be insufficient room to cut the top of the asbestos covered pipe.

Checking for Leaks Before Removal

After abatement, the glove bag must checked for leaks before it is removed from its attachment. Follow these procedures:

- Precut a few pieces of duct tape for patching holes or leaks and set aside.

- Poke a small hole through the prelabeled water hose patch (if present).

  or

  Reinforce a 2-inch section of the glove bag with duct tape (above and to the side of one of the gloves). Slice a small hole through the tape just large enough for the smoke tube end to be put into.

- Hold the smoke tube down into a wastebasket. Carefully snap off one tip of the tube with tin snips Place it into the tubing attached to the aspirator bulb.

  Note: Eye protection should be worn to protect from stray pieces of glass. Also the smoke is a skin and eye irritant.

- Snip off the other end of the smoke tube and place immediately into the hole. Be careful not to puncture other areas of the bag.
- Squeeze the aspirator bulb until the bag fills with visible smoke. Remove the smoke tube and seal the hole with a small piece of duct tape. Once the bag has been sealed, place the tube in a bucket of water for 5–10 minutes. Remove the tube and throw away.
- Gently squeeze the glove bag and look for leaks. Patch all leaks with duct tape.
- Set a HEPA vacuum to the low volume setting and turn it on. Remove the majority of the smoke by placing the vacuum hose over the hole for the smoke tube for a few seconds. Do not fully collapse the bag.

Removal and Cleanup

Removal and cleanup are some of the most important steps in project. Remember: Class I projects require these steps be done by two workers.

- Insert the wand of the garden sprayer through the reinforced hole up to the handle. Tape it securely with duct tape so that there are no leaks.
- All work (except for the water spraying) will now be done through the gloves.
- If an aluminum jacket is present, remove it with tin snips and wire cutters. Fold the sharp edges inward to prevent cutting the bag. Place it gently on the bottom of the bag. Be careful not to cut yourself or your partner on the sharp edges. The insulation should now be exposed.
- Wet the asbestos material thoroughly. Holding the handles of a bone saw, begin cutting through the asbestos. It may be easier to cut the bottom half first. Your partner should spray water on the cutting area and sides of the bag throughout the process. This will keep dust to a minimum. Do not use excessive water. This can weigh down the glove bag and cause it to pull away from the pipe. Support the bottom of the bag if possible. Be careful not to cut through the pipe. A bone saw is extremely sharp.

- While wetting, horizontally cut the top or seam of the insulation from end to end with the utility knife. Be careful not to cut the bag. Gently place the insulation in the bottom of the bag. (Cutting the top of the pipe lagging makes it easier to wet all of the insulation.) Wet the material on the bottom of the bag and any remaining debris on the pipe.

- Clean all debris off the pipe with water, a scrub brush, and rags. Clean off excess debris on the exposed ends of asbestos on the pipe.

- Wet the donut-shaped pieces of re-wettable fiberglass cloth and apply to exposed ends of asbestos. Be sure to enclose all visible insulation.

- Spray down and clean the inside of the bag. Clean the retractable knife, bone saw, wire cutter, and tin snips. The rags and scrub brush cannot be adequately cleaned. Leave them in the bag to be thrown out with the rest of the waste. Be sure the asbestos debris in the bag is wet all the way through.

- Hold the cleaned tools with one glove and invert the glove to the outside of the bag. Tie off the glove with string at two areas and cut the glove between the two sealed areas (Figure 9-5).

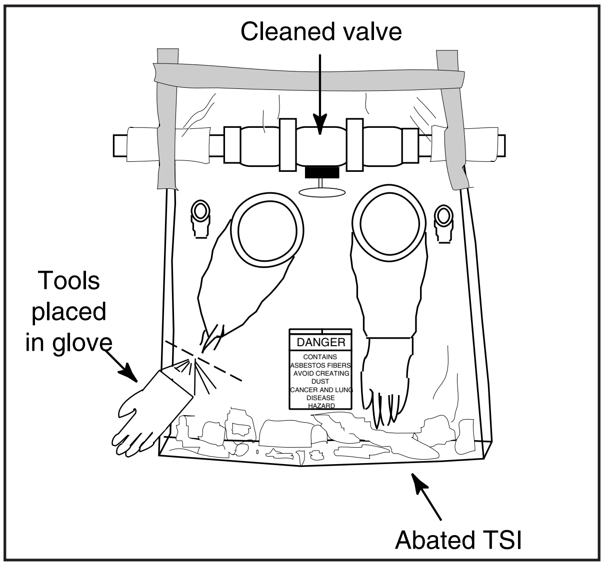

Figure 9-5. Invert the glove to remove tools from glove bag.

- Place the section of glove containing the tools in the water bucket. Open this glove underwater and clean all tools in the water. Remove any gross chunks of debris and place in prelabeled asbestos waste bag. Dispose of glove in asbestos waste bag. The glove also may be put into and opened in the next glove bag without final cleaning of the tools.

- Attach the HEPA vacuum to the bag. With the HEPA vacuum on the low flow setting, gently collapse the glove bag.

- Twist the bag several times at the mid-section (below the water sprayer hole) and tape it. This will isolate the debris in the bottom of the bag while the glove bag is removed from the pipe, as shown in Figure 9-6.

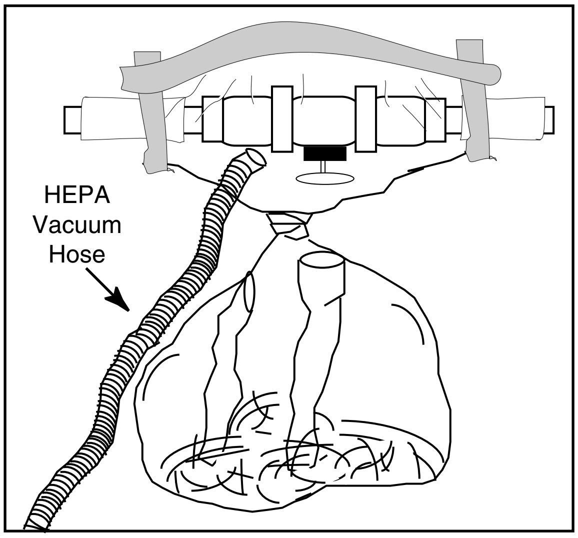

Figure 9-6. Collapse the glove bag with a HEPA vacuum.

- Carefully remove the water wand from the bag.

- Remove the vacuum nozzle.

- Carefully cut the bag off of the pipe without touching the inside of the bag. Seal up the top of the glove bag and place in a 6-mil, labeled bag.

- Remove the disposable suits and place in bag. Fold the poly on the floor inward and place in bag.

- Twist the top of the bag and seal with duct tape. Make sure the bag is properly labeled.
- Remove and clean the respirator. Refer to the PPE section of this manual.
- After rewettable fiberglass cloth has dried, paint over with appropriate encapsulant.

Note: State regulations vary on glove bag procedures. Asbestos and ACM must be disposed of in accordance with state and federal (*EPA*) regulations. Contact your state environmental department for the location of the nearest approved landfill.

WET REMOVAL TECHNIQUES

EPA regulations require wetting the asbestos-containing material before removal begins, and keeping it wet as it is removed and bagged. Dry removal, which requires specific written EPA approval, may be needed for some types of ACMs that have been previously encapsulated and will not absorb amended water.

Wet methods reduce the amount of asbestos dust given off during removal and make it easier to remove ACMs.

Wet removal can be improved by adding a substance called a *wetting agent* to the water. The wetting agent is a combination of chemicals that helps the water soak into the ACM. Water that contains a wetting agent is called *amended water*. It is not as effective with materials that contain a high percentage of *amosite* asbestos.

The first step in the removal process is to thoroughly wet the ceiling material with a low pressure spray of amended water. The material should be sprayed with a light coat of amended water to initially wet the surface, then a saturation coat is applied.

Removal of ceiling material is carried out in two stages—gross and secondary removal. Gross removal is typically conducted with a three-or-four-person team. Two workers on a mobile scaffold with rails remove the friable material using scrapers. Wide blades can be used if the material comes off easily. Workers of approximately the same height should be paired together on the scaffolds. One or two workers on the ground package the moist material, before it has time to dry out, in 6-mil plastic bags or plastic-lined fiber drums. Many states have regulations regarding the maximum height from which asbestos can be dropped (most often 15 feet).

Rubber dust pans, plastic snow shovels, push brooms, and standard house brooms should be used to collect and bag the material. Avoid using metal shovels or dust pans that can tear the poly on the floor.

The crew that bags the material moves the scaffold as needed, relocking the wheels after each move. If several crews are removing material, it may be time-efficient to designate a “spray” person. The spray person walks from one area to the next, wetting the material on the ceiling and the floor and misting the air to keep airborne fiber concentrations low. The spray person can also check for damaged floor barriers and promptly repair them.

Bags containing waste material are processed for waste load-out by:

- Wet-wiping
- Placing in another “clean” bag
- Depositing into fiber drums

After removing as much of the sprayed-on material as possible with scrapers, crews begin secondary removal. Depending on what is underneath the asbestos, various techniques and tools may be required. The wall or ceiling under the asbestos may be smooth, rough, or pitted, and will affect the difficulty of secondary removal. Usually a combination of brushing and wet-wiping are used to remove the remaining residue. Nylon bristle brushes should be used instead of wire brushes, which may break the small fibers into smaller fibers. The rags used for wet-wiping should not leave any fabric fibers on the surface,which could be mistaken for visual contamination. HEPA vacuum cleaners are also useful for removing hard-to-get-to residue.

While crews are working from scaffolds or ladders to remove all remaining residue from the ceilings, workers should also be cleaning material off the poly wall barriers and any stationary objects in the area. Brooms, wet rags, or squeegees are good for this purpose. Secondary removal is finished when all visual contamination is removed from the ceilings. The next phase is final cleanup.

CLEANING UP THE WORK AREA

The information in this section is based on the *Procedures and Practices for Asbestos Abatement Project Manual* developed by Georgia Tech Research Institute and Tufts University with EPA funding.

Although cleanup is a tedious, sometimes lengthy process, it is one of the most critical tasks of the project. Successful clean-up operations require that the tasks be done in the correct order with great attention to detail. If these items are overlooked, much more time may be spent in the recleaning, retesting cycle than would have been spent to initially conduct a thorough, correct cleanup. The steps and details for cleaning up an area where sprayed-on material has been removed are provided in the following discussion. Removal and cleanup operations may vary, depending on specifications and the nature of the project.

Cleanup During Gross Removal

Cleaning the work area begins shortly after workers start removing the ACM from the substrate. Techniques for cleaning the work area during the removal phase are addressed in the section “Controlling Asbestos Exposure During Removal.” In summary, a floor crew wearing appropriate personal protective equipment is responsible for bagging the material soon after it is removed, while it is still damp. The material is collected from the floor with brooms, squeegees, plastic dust pans, or other appropriate tools and placed in 6-mil bags labeled for disposal.

Steps for Final Cleanup

Final cleanup applies to the phase of the project in which all visible ACM has been removed from the substrate and the substrate has been brushed and wet-wiped. The area should be inspected for the removal of gross materials and to ensure that all materials specified in the job specs are removed.

1. Remove gross contamination from equipment in the work area.
2. Remove gross contamination from wall covering or remove outer contaminated layer if two layers were hung.
3. A *competent person* conducts visual inspection of all surface areas. Reclean if necessary.
4. Remove gross contamination from impervious drop cloth. Remove top poly layer if two layers were used.
5. Start removing poly.
6. Perform final wipe down of equipment and remove from work area.
7. Apply sealant to substrate.
8. Wait overnight, then remove poly from the walls.
9. HEPA vacuum.
10. Remove poly floor covering. Remove or clean carpet.
11. HEPA vacuum.
12. Wet-wipe the walls.
13. Wet mop the floors.
14. Wait overnight. Repeat wet-wipe and wet-mop steps.
15. Visual inspection reclean if necessary.
16. Reinspect after finals.
17. Final clearance monitoring.
18. Cleaning up the decontamination unit.
19. Cleaning up the enclosed truck.

PREPARING ASBESTOS WASTE FOR DISPOSAL

The information in this section is based on the *Procedures and Practices for Asbestos Abatement Project Manual* developed by Georgia Tech Research Institute and Tufts University with EPA funding.

The asbestos waste should be kept wet until it is disposed of.

- The first step in disposal is to select 6-mil polyethylene disposal bags. These should be air-tight, puncture resistant, and labeled with the OSHA required statement:

DANGER
Contains Asbestos Fibers
Avoid Creating Dust
Cancer and Lung Disease Hazard

- Materials that may puncture the bags (metal, sharp objects) should not be put in bags. These should be carefully sealed in 2 layers of 6-mil poly.
- Wet wipe or HEPA vacuum any debris from the outside of the bags.
- Place bags in fiberboard drums with locking rims. Generally 4 to 5 bags can be put in each drum.
- Drums should be labeled with the required OSHA label.
- Before each drum is brought into the work area for loading, the outside of the drum should be covered with a large plastic bag (garbage bag). This outside bag should be kept on the drum while it is being filled with the asbestos-containing waste bags.
- Once the drum is filled, lock the lid or rim into place. The drum will then be ready for transportation out of the work area.

- Before leaving the work area (at the doorway to the waste load-out area), remove the plastic bag on the outside of the drum and put it in the next drum to be filled with waste.

- Before the drum enters the load out area, it should be hosed down and/or wet-wiped to make sure there is no contamination left on the outside of the drum.

- Move the sealed drum into the waste load-out area and into the enclosed truck.

  Note: Drums may not be used for asbestos removal in some states, since many of landfills will not accept them.

WASTE LOAD-OUT PROCEDURE

The best method for waste load-out procedure is to use two teams of workers: an inside team and an outside team. The inside team, wearing appropriate respirators and protective clothing, are responsible for ensuring that the drums are properly packed, lids locked into place, and plastic bags removed from the outside of each drum before it is sent through the waste load-out area and into the enclosed truck. It is important that no workers from the inside team exit the work area through the air lock.

In cases where the drums are not covered with plastic bags, the inside team should make sure that each drum taken from the work area is free of all dust. This can be done by inspecting and wet-wiping every drum leaving the area.

The outside team (in the waste load-out area), wearing dual-cartridge respirators and protective clothing, are stationed at the entrance to the work area. The inside team passes the drums into the load-out area. From here, the outside team loads the drums into the enclosed truck. The entrance into the waste load-out area from the work area should then be secured to prevent any unauthorized entry or exit.

The outside team brings the drums into the air lock and up the ramp so the drums can be safely stored in the enclosed truck. Drums should be placed on level surfaces in the cargo area and packed tightly together to prevent shifting and tipping. Under no circumstances should containers ever be thrown into the cargo area.

The inside or "bed" area should be lined with two layers of 6-mil polyethylene. First, the floor should be completely covered with a 6 inch overlap of each piece. The same method should also be used when lining the sides and top of the cargo area. Duct tape would be used to properly secure the sheets of poly. This will not only enclose the asbestos-containing waste, but makes cleanup easier. Any debris or residue observed on containers or surfaces outside of the work area, resulting from disposal activities, should be immediately cleaned by using HEPA-filtered vacuum equipment and/or wet-wiping, as appropriate.

Waste Load-out Through Decontamination Chambers

Many asbestos abatement sites require that bags of asbestos waste be removed through the decontamination chambers. This is accomplished with three crews of workers:

- The workers inside the work area make sure that there are no rips in the bags, that there is no excess air in the bags (so the bags do not burst when others are piled upon them), and that the bags are wiped clean of gross contamination. The bags are then passed into the "dirty room" or equipment chamber to a worker waiting there.

- The worker in the equipment room passes the bag only into the shower area and puts it into a second bag being held by a worker standing in the clean or change room. No worker should be in the shower room. The worker in the clean room then seals the second bag with duct tape, again letting out excess air. The double bagged waste is passed out to a crew on the outside.

- The outside crew places the double-bagged waste in a transport and, when it is full, removes the transport to the truck.

- Once the waste is on the truck procedures for drum removal are used.

Other Forms of Asbestos-Containing Waste

There are many cases when it will be necessary to dispose of materials, such as asbestos-containing floor, wall, or ceiling tiles, shingles, rugs, etc., that will not fit in or might puncture the bag. The general rule in these instances is simply good common sense. This may include neatly banding together tiles or shingles with care not to expose sharp edges or any other protruding objects that might puncture the polyethylene enclosure. Once the materials are banded together, each bundle should be wrapped in two layers of 6-mil poly. When this is complete, the bundles should be neatly stacked in the cargo area of the truck. Care should be used so that tipping or shifting of the load is prevented.

TRANSPORTATION TO DISPOSAL SITE

As work progresses, and to prevent exceeding available storage capacity on-site, sealed and labeled containers of asbestos-containing waste should be removed and transported to the prearranged disposal location. Regulations may vary from state to state, but there are standard procedures that must be followed in any operation involving asbestos waste disposal. Disposal must occur at an authorized site in accordance with regulatory requirements of National Emission Standard for Hazard Air Pollutants (*NESHAP*) and state and local guidelines.

Disposal at the Landfill

Once the asbestos-containing waste truck arrives at the landfill, the driver gets as close as possible to the disposal location for unloading of the water materials. Bags should then be taken out of the drums along with the other waste components. They should be inspected as they are off-loaded. If a bag has been damaged, the material should be repacked in another bag as appropriate. There may be some instances in which the drums can be buried at the landfill; however, it is usually more economical to reuse the drums.

Waste bags should be placed on the ground at the disposal site—not pushed or dropped out of the trucks—as the weight of the wetted material could rupture the containers. Workers unloading the containers should wear proper protective equipment, including disposable head, body, and foot protection. A half-face, air-purifying, dual-cartridge respirator equipped with high-efficiency filters should be worn.

After all the waste has been unloaded, the truck cargo area should be decontaminated using HEPA vacuums and/or wet-wiping methods to comply with the OSHA "no visible residue" and EPA "no visible emission" criteria. The polyethylene sheeting should be removed and discarded along with contaminated cleaning materials and disposable protective clothing in other bags and/or drums at the disposal site. The landfill personnel should have their own personal protective equipment. However, if this is not the case, the contractor should supply them with protective clothing and respiratory protection.

The bags or drums should be placed intact in an excavated area and covered with a minimum of 6 inches of earth at the end of each working day. These areas must be clearly marked to prevent future disturbance of the waste.

Waste Water Disposal

Special precautions must be taken to dispose of the run-off from showers in the worker decontamination area. Water should be filtered through a five micrometer pore size filter. This filtered water can be disposed of in a sanitary sewer system. If there is no sewer system, the filtered water can be disposed of into a septic tank and field system with adequate capacity. The filter must be handled and disposed of along with the rest of the asbestos waste.

SECTION 9 - ASSIGNMENT SHEET

1. Define the following acronyms or terms:

   Amended water ______________________________

   ____

   Encapsulation ______________________________

   ____

   Enclosure ______________________________

   ____

   Glove bag ______________________________

   ____

   HEPA vacuum ______________________________

   ____

   NESHAP ______________________________

   ____

2. Describe the difference between bridging and penetrating sealants.

   ____

   ____

   ____

   ____

3. List the three advantages and seven disadvantages of encapsulation.

Advantages	Disadvantages

4. List the three advantages and seven disadvantages of enclosure.

Advantages	Disadvantages

5. List ten tools commonly used with a glove bag.

6. Describe the two stages of asbestos abatement.

7. List the 19 steps to the final cleanup.

9

ASBESTOS ABATEMENT WORKER REFRESHER

Section
10

Title
AIR MONITORING

TRAINEE OBJECTIVES

After completing Section 10, you will be able to:

1. Define the following terms or acronyms:

   Aggressive sampling
   Area sampling
   Breathing zone
   Bulk sampling
   FAM
   PCM
   Personal sampling
   PLM
   Static sampling
   TEM

2. Explain why and how air sampling is done on an asbestos abatement project.
3. Explain the difference between static sampling and aggressive sampling.
4. Describe bulk sampling, settled dust sampling, and wipe sampling methods.
5. List and briefly describe the limitations of the four analytical methods used in asbestos abatement.
6. Explain the purpose for taking area sampling results from outside the work area (but inside the building) and from outside the building.
7. List the two microscopy methods used in final clearance of asbestos abatement projects.

INTRODUCTION

An asbestos abatement project always has the potential of containing dangerously high levels of asbestos fibers from which workers must protect themselves. The various methods and techniques for monitoring and sampling asbestos are described in this section.

SAMPLING METHODS

There are a number of sampling techniques used throughout asbestos abatement projects. Each has a different purpose. These methods include:

- Air sampling
- Bulk sampling
- Settled dust sampling
- Wipe sampling
- Analytical methods

Air Sampling

Air sampling is done to determine the levels of asbestos fibers in the air before, during, and after abatement activities. The two basic types of air sampling are area sampling and personal sampling.

Sampling is conducted with battery-powered and electric pumps. A plastic cassette, which holds a filter with very small pore openings, is attached to the pump with flexible tubing. With the front cover of the cassette removed, air is drawn through the filter, and particles in the air are collected on the filter surface. The type of filter used for sampling depends on the technique that will be used for analysis.

Area Sampling

Area samples are taken with a filter that is placed at *breathing zone* (attached to or near the collar or lapel near the worker's face) height at some fixed location. The top cover of the plastic filter holder is removed, and the filter holder is pointed downward to prevent material from falling onto the filter. The pump is turned on and the start time, air flow rate, and sample description are recorded. The pump should be checked regularly to make sure it is working properly. Also, the filter should be visibly inspected for overloading. At the end of the sampling period, the pump is turned off and the cover of the filter holder is replaced and secured with tape. The stop time, air flow rate, and any other comments about sampling conditions are then recorded.

Area air samples can be collected using *static sampling* or *aggressive sampling* techniques.

Static Sampling

Static sampling means monitoring an area as it is without creating any additional disturbance in the air. This method is typically used during the removal phase of the abatement project.

Aggressive Sampling

Aggressive sampling addresses the concern of detecting settled fiber by creating an artificial disturbance in the air during sampling. Aggressive sampling can be done with electric fans, sweeping, blowers, etc.

Personal Sampling

Personal samples are collected from within the breathing zone of an individual, but outside the respirator. Personal samples are collected in the same manner as area samples except the pump is hung from a disposable tape belt around the worker's waist and the filter holder is attached, pointing downward, to the worker's lapel or collar. Figure 10-1 shows a personal air sampling pump.

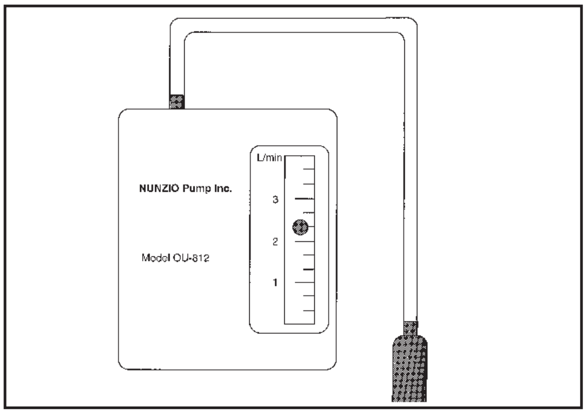

Figure 10-1. A personal air sampling pump used in air monitoring.

Bulk Sampling

Bulk sampling is accomplished by collecting samples of suspect materials, such as fireproofing, pipe lagging, boiler insulation, and acoustical spray. It is usually done during the building survey/hazard assessment and provides data for decisions on control measures. A small sample of suspect material is collected and placed in a container.

Settled Dust

Settled dust samples are collected either by wet-wiping or by using a personal sampling pump and cassette as a vacuum to collect dust that has settled on surfaces.

Wipe Sampling

Wipe sampling is used to determine trace amounts of asbestos on surfaces. A filter material is used to wipe an area and is submitted to the laboratory for analysis.

Analytical Methods

Asbestos is identified and concentrations determined with the use of various types of microscopes. The technique used to analyze asbestos is called microscopy.

Polarized Light Microscopy

Polarized light microscopy (PLM) is used to identify asbestos in bulk samples. It cannot resolve or identify small diameter fibers.

Phase Contrast Microscopy

Phase contrast microscopy (PCM) is used to count asbestos fibers on filters. It cannot identify fiber type, but can resolve small fibers. The PCM method is the same for both types of samples (personal or air clearance), but the sample collection procedures are different.

Transmission Electron Microscopy

Transmission electron microscopy (TEM) can both resolve and identify small fibers. The disadvantages of TEM are:

- High cost – $300 to $500 per sample. EPA recommends 10 samples per work area.
- Slow turnaround time – 1 to 5 days.
- Usefulness of results – The results are used for final air clearances or occupancy standards and cannot be used for determining which respirator to wear.

The Fibrous Aerosol Monitor

The *fibrous aerosol monitor (FAM)* is an instrument that uses laser light and electrical field technologies to analyze the fiber content of the air. The FAM provides a continuous measurement, with a direct readout of the concentration of airborne fibers. It can be used in conjunction with a printout called a strip chart to provide a record of air quality conditions.

The FAM does not distinguish fiber types and cannot discriminate between fibers and certain particles that have fiber characteristics. The FAM does not detect fibers less than 0.5 micrometers in diameter, which may be the majority of the fibers present in the air.

Sampling Procedures

An asbestos abatement project requires a combination of sampling techniques and methods, performed at various times throughout the project, to ensure worker safety. Following are procedures to use when air sampling on an asbestos abatement job site.

Before Abatement Begins

Area air sampling is conducted before abatement activities begin. Estimating the existing airborne fiber concentrations inside and outside the building is termed prevalent level sampling. These results can be used for comparing sample concentrations detected during and after the abatement project. This sampling is particularly useful when an abatement project is conducted in a portion of the building with other areas of the building remaining occupied. Airborne fiber levels monitored in the occupied areas during the abatement project should never be higher than the prevalent level in these areas before the project began.

Prevalent samples should be collected throughout the building, as well as in the areas where abatement will take place. As a general rule, one sample should be taken for every 50,000 cubic feet (5,000 square feet with 10 foot ceilings) of building space. A minimum of three samples should be taken. At least two samples should be collected from outside the building. Air samples should be taken both inside and outside of the building to see whether differences exist.

During and After Abatement

Personal sampling is conducted during the first phases of an abatement project to determine worker exposure (outside any respirator) to airborne fibers. This is known as the *initial exposure assessment*. The purpose of this assessment is to ascertain the expected worker exposure.

Monitoring Worker Exposure

Data from personal monitoring serve many purposes. Personal monitoring during an abatement project is required by the Occupational Safety and Health Administration (*OSHA),* Asbestos Standard for

Construction 29 CFR 1926.1101. Under this standard and hazard communication laws, workers have the right to know the asbestos concentrations to which they are exposed and what is being done to protect them.

On Class I abatement projects, the employer must presume that the workers' exposure to asbestos is in excess of the *time weighted average* (*TWA*) and excursion limits. This presumption must be made until after a *negative exposure assessment* (*NEA*) can be conducted.

An NEA is an assessment to prove that worker exposure is below the TWA for asbestos. It must use objective data demonstrating that the activities involving the asbestos-containing product cannot release airborne fibers in excess of the TWA. If the initial monitoring conducted at the beginning of the project shows exposure results indicative of the exposures that will take place during abatement, these results can serve as the objective data needed for the NEA.

If the contractor has monitored a job site in the past 12 months and the conditions of that job site are "closely resembling" the conditions at the current site, this information can be used to substantiate the assessment. But for these jobs to be considered "closely resembling" the processes, materials, control methods, work practices, and environmental conditions must be the same. Also, the training received by the workers on the current site must be equal to or greater than the training of the workers who were involved on the previous project.

Results of personal sampling can be used to select proper respiratory protection for an employee if conditions warrant something other than Type C pressure demand respirators (See "Personal Protective Equipment" section of this manual). Data from personal monitoring can be used as an indication of effective removal or control techniques that result in the lowest employee exposure. This, in turn, reduces the chance of asbestos-related diseases and the risk to the worker.

Personal air samples should be collected daily to determine which respirator to wear unless Type C pressure demand respirators are being used. Personal sampling should be performed initially and every six months thereafter, according to OSHA. Samples should be representative of the entire 8-hour work shift.

Sampling Inside the Work Area

In addition to personal samples, area air samples are collected inside the work area daily to determine the concentrations of airborne asbestos fibers. Several samples may be needed to index the airborne fiber concentrations inside the work area. These samples can be used to monitor work conditions from one day to the next. A large increase in area concentrations would signal that work practices need to be adjusted.

Sampling Outside the Work Area/ Inside the Building

During an abatement project, samples are collected from locations outside the work area, but inside the building, to determine how well asbestos fibers are being contained in the work site. These samples are especially important in situations where unprotected people are occupying other areas of the building.

Potential leakage points where sampling should be conducted include the clean side of the containment barriers separating the work area from occupied parts of the building and inside the shower and clean rooms of the decontamination unit. If the abatement project is being conducted in a multi-story building, area air samples should be collected from floors above and below the abatement activity.

Sampling Outside the Building

Area air samples are placed in locations outside of the building during an abatement project to detect leakage of fibers from the work site and to establish baseline levels of airborne asbestos.

Sampling After Final Cleanup

Area air sampling is conducted when an asbestos abatement project is finished to estimate the airborne fiber concentrations that may be left behind. The area must pass a thorough visual inspection for remaining material before final clearance sampling is initiated. Samples are taken inside the work area and inside the building, but outside the work area. It is also important to take outdoor air samples for comparison. The number of samples needed depends on the size and layout of the work area.

Ideally, PCM and TEM are used in combination as a two-stage process for final clearance sampling. PCM analyses can be used to determine if any gross contamination remains in the work area. Side-by-side samples can be taken for analyses by TEM.

If the PCM samples indicate airborne fiber levels are below 0.01 fibers/cc using aggressive sampling techniques or, by comparison, lower than outside air samples, then the other set of samples are submitted for analyses by TEM. As discussed earlier, TEM is the analytical method recognized as having the best resolution and positive fiber identification capabilities.

The airborne fiber concentration for clearance by TEM is also 70 structures/square millimeter (s/mm^2) with aggressive sampling or concentrations lower than indicated by the outside air samples, whichever is higher. If the results by TEM analysis indicate the airborne fiber concentrations are higher than this clearance standard, then the area should be recleaned and retested until the criterion is met.

An argument for using only PCM to perform final clearance sampling is that the turnaround time and cost for TEM analysis is prohibitive. Proper planning should allow time between initial clearance monitoring and reoccupancy for any necessary recleaning and retesting.

SECTION 10 - ASSIGNMENT SHEET

1. Define the following acronyms or definitions:

   Aggressive sampling ______________________________

   ____

   Area sampling ______________________________

   ____

   Breathing zone ______________________________

   ____

   Bulk sampling ______________________________

   ____

   FAM ______________________________

   ____

   PCM ______________________________

   ____

   Personal sampling ______________________________

   ____

   PLM ______________________________

   ____

   Static sampling ______________________________

   ____

   TEM ______________________________

   ____

2. Explain why and how air sampling is done on an asbestos abatement project.

____

____

____

____

____

3. Explain the difference between static sampling and aggressive sampling.

____

____

____

____

____

4. Describe bulk sampling, settled dust sampling, and wipe sampling methods.

Bulk sampling ____

____

____

Settled dust sampling ____

____

____

Wipe sampling ____

____

____

5. List and briefly describe the limitations of the four analytical methods used in asbestos abatement.

6. Explain the purpose for taking area sampling results from outside the work area (but inside the building) and from outside the building.

Outside the work area, but inside the building

Outside the building

7. List the two microscopy methods used in final clearance of asbestos abatement projects.

ASBESTOS ABATEMENT WORKER REFRESHER	Section 11
	Title HAZARD COMMUNICATION

TRAINEE OBJECTIVES

After completing Section 11, you will be able to:

1. Define the following terms or words:

Administrative controls	Substitution
Engineering controls	Time weighted average

2. Identify the following acronyms:

ACGIH	NFPA
DOT	NIOSH
IDLH	PEL
MSDS	TWA

3. List the requirements of the Hazard Communication Standard's written program.

4. List the basic information that must be covered in the employer's training program for hazard communication.

5. List the information an employer must provide each employee.

6. List the exposure control measures that protect workers from exposure.

7. Demonstrate how to use MSDSs by completing an assignment sheet.

8. List the information that must be given on a typical label.

9. List the three basic types of labeling systems.

10. Demonstrate how to read a label by completing an assignment sheet.

11. Calculate TWA and determine exposure levels.

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INTRODUCTION

An effective Hazard Communication Program needs the cooperation of both employers and workers alike. The employer must provide workers with specific information and training about hazardous chemicals in the work area. You must use the information and training to recognize chemical hazards in the work area and take steps to prevent exposure.

HAZARD COMMUNICATION STANDARD

The Occupational Safety and Health Administration (*OSHA*) has implemented the Hazard Communication Standard for both the construction industry (29 *CFR* 1926.59) and general industry (29 CFR 1910.1200). The standard states:

> The purpose of this section is to insure that the hazards of all chemicals produced or imported are evaluated and that information concerning their hazards is transmitted to employers and employees.

These standards require that manufacturers of hazardous chemicals inform employers about hazards relating to their products. The employer must inform all workers who will use or come into contact with the chemical about these hazards.

Scope

The Hazard Communication Standard applies to any chemical known to be present in the workplace to which you may be exposed during normal use. It also applies when exposure to chemicals may occur during a foreseeable emergency. On an asbestos abatement site, the standard only applies to the hazardous materials or substances used for the clean-up process. The standard does **not** apply to:

- Alcoholic beverages
- Articles (chairs, tables, etc.)
- Consumer products
- Food, drugs, and cosmetics
- Hazardous waste
- Tobacco or tobacco products
- Wood or wood products

You must be trained in the standard because of the hazardous materials used for cleanup. In order to use the standard correctly, you must know the difference between hazardous substances and hazardous waste.

Hazardous substances or materials are any substances or materials which in normal use can be damaging to the health and well-being of workers and the environment. Examples of normal use include processing plant work, manufacturing, and chemical decontamination. Hazardous substances or materials cover a broad range of types, such as toxic, corrosive, and flammable.

Hazardous waste is a hazardous substance that has been discarded or otherwise designated as a waste material. It contains the same potential for damaging the health and well-being of workers and the environment.

Hazard Determination

The Hazard Communication Standard requires chemical manufacturers, importers, and employers to determine if the chemicals or substances they produce, import, or use in the workplace are hazardous. In most cases, hazard determinations are done by chemical manufacturers before the chemicals are sold to customers.

Written Hazard Communication Program

Under the standard, employers and/or contractors must develop, implement, and maintain a written Hazard Communication Program. This written program must be available at the workplace and provide the following information:

- List the hazardous chemicals on the job site.
- Explain how the employer will inform workers of the hazards associated with nonroutine tasks involving hazardous chemicals.
- Explain labels and other forms of warning used by the employer.
- Explain how workers will be provided with material safety data sheets (*MSDSs*).
- Describe the training the employer will use to teach workers about hazardous chemicals.

Multiple Employer Sites

Some asbestos abatement sites have more than one employer working on the site at the same time. The standard requires that all employers on a multiple employer site provide information to each other on the hazardous chemicals they are using. This sharing of information will help prevent exposure to chemical hazards from another employer. The written Hazard Communication Program of a multiple employer site must:

- Explain how MSDSs will be provided to the other employer(s), or identify the location of the MSDSs for each hazardous chemical the other employer's workers may be exposed to while working.
- List the methods an employer will use to inform other employer(s) of measures that need to be taken to protect workers during normal operating conditions and in foreseeable emergencies.
- Explain how the employer will inform the other employer(s) of the hazardous chemical labeling system being used.

The written Hazard Communication Program must be made available upon request to you, your representatives, and OSHA.

Information and Training

The Hazard Communication Standard requires employers to provide specific information and training on hazardous chemicals so you will:

- Be aware of the hazardous chemicals used on the job
- Know how to recognize these hazardous chemicals
- Know the safety issues and health effects of the hazardous chemicals
- Be able to protect yourself

As a minimum, training must cover the following hazard communication information:

- Requirements of the Hazard Communication Standard.
- Operations in the work area where hazardous chemicals are present.
- Location and availability of the:
  - Written Hazard Communication Program
  - List of hazardous chemicals
  - MSDSs for all hazardous chemicals used on site

Employers must provide or ensure that workers have been provided with the following information:

- The ways to detect the presence or release of hazardous chemicals in the work area. Characteristics of a chemical are important pieces of information for workers. These characteristics include color, chemical state (solid, liquid, gas), and odor.
- The physical and health hazards caused by exposure to the hazardous chemicals on the job.
- How to protect yourself through work practices, personal protective equipment (*PPE*), and emergency procedures.
- Details of the Hazard Communication Program used by the employer, including labels, lists, MSDSs, and how you can get and use hazard information.

Note: This section covers the general information that must be included in the Hazard Communication Program. The section does not fulfill an employer's obligation to supply you with hazard communication training on site-specific hazards.

EXPOSURE GUIDES

When working around hazardous chemicals, exposure is an important consideration. Hazardous chemicals can have devastating health effects on the human body. Therefore, exposure guides are used to inform you about warnings and exposure limits and to make decisions about your exposure to chemicals.

Some exposure guides are general. They give instructions or information about a chemical using a short phrase, word, numbers, or symbols. For example, “avoid skin contact” and “avoid breathing vapors” are general exposure guides. These general guides are usually found on labels or placards on chemical containers. However, identity of the chemical needs to be known in order for general guidelines to be useful.

When the the employer knows both the identity of a chemical and its air concentration at the work site, more specific exposure guides can be applied. Permissible exposure limits (*PELs*) and threshold limit values (*TLVs*) are two commonly used exposure guides that deal with concentration levels.

Exposure limits set the basis for safe working exposures. In most cases, exposure limits refer to concentrations of a toxic substance in the air over a normal 8-hour work shift. Safe exposure limits represent conditions under which nearly all workers can be repeatedly exposed day after day without adverse acute or chronic health effects.

An MSDS for a product must list chemical exposure limits. The limits may also appear on the product’s container label. Exposure limits usually are given as parts per million (*ppm*) or milligrams per cubic meter (mg/m^3). One ppm is like one drop of chocolate in 14 gallons of milk. Many chemicals can affect your body at 1 ppm or even smaller amounts.

Several organizations have published, required, or recommended safe working guidelines for exposures to hazardous chemicals. These organizations are OSHA, the National Institute of Occupational Safety and Health (*NIOSH*), and the American Conference of Governmental Industrial Hygienists (*ACGIH*).

Permissible Exposure Limits

PELs are exposure guides for airborne concentrations of regulated substances. They set limits on a worker's inhalation exposure or the amount of substance you can legally breathe in a set amount of time.

There are three ways to represent PELs:

- Time weighted average
- Short-term exposure limit
- Ceiling limit

PELs are the **only** legally enforceable limits because they are set by OSHA. This means that by law, employers must keep your exposure below the PEL. PELs are meant to offer the minimum levels of protection. However, more protective limits are always allowed.

Because PELs refer to inhalation exposures, they cannot be used to determine exposure that occurs through the skin. You can have an exposure below the PEL but still become overexposed to a chemical through skin absorption.

The skin notation that is sometimes listed in the PELs means a chemical can be absorbed through the skin. It is **not** an exposure guide. There are no concentration guidelines for skin exposure. Therefore avoid skin contact with chemicals whenever possible, especially when the skin notation is used.

Note: PELs are important for protecting you from overexposure to hazardous chemicals. However, you should be aware of the drawbacks of PELs. Many PELs are not set to protect you from chronic health effects such as cancer. In addition, PELs that apply to the construction industry were established in 1970. Although OSHA has updated PELs for some substances since that date—such as lead and asbestos—there are many PELs that are outdated.

Time Weighted Average

Time weighted average (*TWA*) is the average concentration of a substance in an area over an 8-hour work shift of a 40-hour work week. To determine a TWA, exposure levels are collected over a work shift. The exposure levels are averaged out for 8 hours and the results compared with OSHA's PEL lists. For example, assume your exposure to toluene is 90 ppm for 2 hours, 120 ppm for 1 hour, and 20 ppm for 5 hours. Your actual exposure to toluene, averaged for the day is 50 ppm. The calculations are shown in Figure 11-1. The allowable TWA exposure for toluene is 100 ppm. Therefore, on this particular day, your were not overexposed according to OSHA limits.

$$\text{TWA} = \frac{(90\text{ ppm x } 2\text{ hrs}) + (120\text{ ppm x } 1\text{ hr}) + (20\text{ ppm x } 5\text{ hrs})}{8\text{ hrs}}$$

$$\text{TWA} = \frac{180\text{ ppm hrs} + 120\text{ ppm hrs} + 100\text{ ppm hrs}}{8\text{ hrs}}$$

$$\text{TWA} = \frac{400\text{ ppm hours}}{8\text{ hrs}}$$

$$\text{TWA} = 50\text{ ppm}$$

Figure 11-1. TWA calculations determine your exposure levels.

Overtime Calculations

If you work longer than eight hours, overtime calculations must be done to determine the total exposure (Figure 11-2). Overtime does **not** allow an employer to expose you to higher concentrations. In fact, you must be exposed to lower concentrations because you will be working for a longer time period.

Overtime Calculations:

Equation: $\frac{\text{PEL x 8 hrs.}}{\text{hrs. worked}}$

PEL = 100 ppm
Hours Worked = 10

Calculation: $\frac{\text{100 ppm x 8 hrs}}{\text{10 hrs}}$ = 80 ppm

Worker can only be exposed to 80 ppm for the duration of the time worked.

Figure 11-2. Overtime exposures must also be calculated.

Mixture Calculations

If you are exposed to more than one substance or to a mixture of substances that have similar chemical properties, mixture calculations must be done to determine your actual exposure. Chemicals with similar properties have a tendency to attack the same target organs which increases the chance of overexposure. Figure 11-3 gives an example of a mixture calculation.

1. Calculate exposure for each chemical: Exposure = $\frac{\text{TWA}}{\text{PEL}}$

Benzene TWA = .5 ppm
PEL = 1 ppm
$\frac{\text{.5 ppm}}{\text{1 ppm}}$ = 50% of PEL

Toluene TWA = 80 ppm
PEL = 100 ppm
$\frac{\text{80 ppm}}{\text{100ppm}}$ = 80% of PEL

2. Add exposures for each chemical to find total chemical exposure:

TOTAL 50% + 80% = 130%

Exposure is 130% of the PEL so the **worker is overexposed.**
Exposure is 30% above the PEL so the **worker is overexposed.**

Figure 11-3. Mixture calculations for exposure to benzene and toluene.

Short-Term Exposure Limits

Short-term exposure limits (*STELs*) are the maximum concentration levels that you can be exposed to for a short period of time (usually 10 to 15 minutes) without suffering from adverse health effects. These health effects include:

- Irritation
- Chronic or irreversible tissue damage
- Dizziness sufficient to increase the risk of accidents, impair self-rescue, or reduce efficiency

STELs should **not** occur more than four times per shift, and there should be at least 60 minutes between exposures. The daily TWA PEL must not be exceeded.

Not all chemicals have assigned STELs. For substances without STELs, it is usually recommended that exposure should not exceed three times the PEL for a short term (10 to 15 minutes). For example, OSHA's PEL for perchloroethylene or perc is 25 ppm. Perc has no STEL listed, so an STEL is estimated by calculating:

3 x 25 ppm = 75 ppm

Ceiling Limits

Ceiling limit (*c*) is an exposure level that should **never** be exceeded. However, not all chemicals have assigned ceiling values. If a ceiling limit is not assigned to a substance or chemical, it is generally recommended that exposures never exceed five times the PEL.

Threshold Limit Values

Threshold limit values are set by the ACGIH. They are based on the best available information from industrial experience, experimental human studies, and animal studies. The basis on which the values are established may differ from chemical to chemical. TLVs are only advisory and are not legally enforceable. A revised list of TLVs is published each year which makes them more current than PELs. However, chronic effects are not always given enough consideration in setting TLVs.

As with PELs, TLVs refer only to inhalation exposures. There are no concentration guidelines for skin exposure. Steps should be taken to avoid skin contact with chemicals, even if the TLV is within the standard. Overexposure to some chemicals can still occur by skin absorption.

Some chemicals cause adverse health effects if short-period exposures exceed a certain level. Special exposure limits are set for these chemicals. As noted previously, ceiling limits (c) are levels of concentration or exposure that can never be exceeded. *Immediately dangerous to life or health* (IDLH) values identify an exposure level in an environment that is likely to cause death or serious health effects with very brief exposures.

EXPOSURE CONTROL MEASURES

Exposure control measures were developed to protect workers from chemical exposure and include:

- Substitution
- Engineering controls
- Administrative controls
- PPE

Substitution is the most desirable control measure because it eliminates the original hazard. The hazardous chemical is replaced with a nonhazardous or less hazardous chemical that works as well.

Engineering controls reduce or eliminate exposures by using mechanical means, such as ventilation systems, acoustical material, and clean air control booths. It does not eliminate the hazard.

Administrative controls reduce exposures to an acceptable limit in two ways:

1. Removing the worker from exposure after a specific length of time. This method is used extensively by the nuclear industry to reduce radiation exposures.
2. Establishing work rules, such as no eating, no drinking, or no smoking.

PPE is the least desirable exposure control measure because the hazard is still present so exposure is possible. However, it is also the most commonly used method in construction. PPE includes respirators, gloves, protective suits, boots, and other gear that are worn to protect workers from exposures. PPE is not an engineering control.

INVENTORY LISTS

Every employer who uses or stores hazardous chemicals on a job site is required to develop and make available a chemical inventory list. This list identifies the potentially dangerous chemicals that you may be exposed to on a work site. The chemical or product name located on the employer's chemical inventory list must be the same as the name on the container label and its corresponding MSDS. In this way,you can easily locate any additional information needed for protection.

The inventory list must be on the job site and available for your review. It is updated whenever any new chemical or substance is brought to the site, or if a chemical is no longer used. A sample chemical inventory list is shown in Figure 11-4.

THIS COMPANY, INC.
111 MAIN STREET
ANYWHERE, U.S.A 12345

CHEMICAL INVENTORY LIST

Acrylic Water Base Paint (Lambert)
Ater Blasting Shop Primer Red 53-R-101
Cosmiscoat Pavement Sealer
Deck Paint Blue Gray 58-F-23 (Mobile Chemical Co.)
Deck Paint Brown 58-D-95 (Mobile Chemical Co.)
Deck Paint Ocean Gray 58-F-14 (Mobile Chemical Co.)
Duracrylic Extra High Gloss Thinner (PPG Industries)
E Enton 37-127 Epoxy Resin (Reichold Chemical)
E Enton 37-620 Epoxy Resin Hardener (Reichold Chemical)
Paint Thinner 21-263 (PPG Industries)
2 - Propanol Solvent (Fisher)
Styrofoam Plastic Forms (Dow Chemical)
Varsol 1 Petroleum Solvent (Exxon)
Varsol 18 Petroleum Solvent (Exxon)

Figure 11-4. A chemical inventory list is a printed record of the chemicals used on a job site.

MATERIAL SAFETY DATA SHEETS

A *material safety data sheet* (*MSDS*) is the primary source of information about hazardous chemicals used on a hazardous waste site. Employers are required to have an MSDS for every hazardous chemical used or stored on each job site. They must make the MSDSs available to you or your union representative for review.

MSDSs come in many different formats, but they all must contain the same basic information. Table 11-1 lists the minimum information that must be contained in every MSDS. Figure 11-5 shows a sample MSDS for the solvent WD-40®.

Table 11-1. The basic information about hazardous chemicals are required minimum information on the MSDS.

MSDS Section Title	Information Included
Product Identity and Manufacturer's Information	• Identity of the chemical (as on label) • The name and address of the manufacturer • Emergency phone numbers • Date when MSDS was prepared
Hazardous Ingredients	• Hazardous ingredients • Properties of the chemical • Common name and trade name • OSHA PELs • ACGIH TLVs • Other recommended limits
Physical/Chemical Characteristics	• Boiling point • Vapor pressure and density • Solubility in water • Appearance and odor • Evaporation rate • Melting point
Fire and Explosion Hazard Data	• Fire and explosion hazard data • Flash point • Flammable limits • Extinguishing media • Special firefighting procedures • Physical hazards
Reactivity Data	• Stability of the substance • Conditions to avoid • Incompatibility with other materials • Hazardous decomposition properties • Associated by-products
Health Hazard Data	• Acute (short-term) health hazards • Chronic (long-term) health hazards • Routes of entry • Target organs • Carcinogenicity (cancer-causing) • Signs and symptoms of exposure • Medical conditions aggravated • Emergency first aid procedures
Precautions for Safe Handling and Use	• Precautions for safe handling • Precautions for safe use • Spill containment procedures • Waste disposal methods • Precautions for storage
Control Measures	• Exposure control measures • Engineering controls • Administrative controls • Work practices • Personal protective equipment

IDENTITY (as used on label and list)	
WD-40®	

SECTION 1 Product Identification

Manufacturer's Name	**Emergency Telephone Number**
WD-40® Company	1-800-424-9300 (CHEMTREC)
Address	**Telephone Number for Information**
1061 Cudahy Place (92110)	1-619-275-1400
P.O. Box 80607	**Chemical Name:**
San Diego, California	Organic Mixture
92138-0607	**Trade Name:** WD-40 Aerosol

SECTION 2 Hazardous Ingredients/Identity Information Hazardous Components (Specific)

		Exposure Limit	
Chemical Name	**CAS Number**	**OSHA/ACGIH**	**%**
Aliphatic Petroleum Distillates	8052-41-3	100 ppm PEL	50
A-70 Hydrocarbon Propellant	68476-85-7	1000 ppm PEL	25
Petroleum Base Oil	64742-65-0	5 mg/m^3 TWA (mist)	>15
Nonhazardous Ingredients			<10

SECTION 3 Physical/Chemical Characteristics

Boiling Point	NA	Evaporation Rate	Not determined
Vapor Density (Air = 1)	Greater than 1	Vapor Pressure	55±5 PSI @ 70°F
Solubility in Water	Insoluble	Appearance	Light amber
Specific Gravity (H_2O = 1)	.710 @ 70°F	Odor	Characteristic odor
Percent Volatile (volume)	80%		

SECTION 4 Fire and Explosion Hazard Data

Flash Point (Method Used)	NA to aerosol cans
Flammable Limits	(propellant portion) **LEL** 1.8% **UEL** 9.5%
Extinguishing Media	CO_2, Dry Chemical, Foam
Special Firefighting Procedures	None
Unusual Fire/Explosion Hazards	EXTREMELY FLAMMABLE - U.F.C. level 3 aerosol

Figure 11-5. This figure portrays the material safety data sheet for WD-40®.

SECTION 5 Health Hazard/Routes of Entry

Threshold Limit Value
Aliphatic Petroleum Distillates (Stoddard solvent) lowest TLV (ACGIH 100 ppm)

Symptoms of Overexposure

Inhalation (Breathing):	May cause anesthesia, headache, dizziness, nausea, and upper respiratory irritation
Skin Contact:	May cause drying of skin and/or irritation.
Eye Contact:	May cause irritation, tearing, and redness.
Ingestion (swallowed):	May cause irritation, nausea, vomiting, and diarrhea.

First Aid Emergency Procedures

Ingestion (swallowed):	Do not induce vomiting, seek medical attention.
Inhalation (breathing):	Remove to fresh air. Give artificial respiration if necessary. If breathing is difficult, give oxygen.

DANGER!

Aspiration Hazard:	If swallowed can enter lungs and may cause chemical pneumonitis. Do not induce vomiting. Call physician immediately.

Suspected Cancer Agent
Yes___ No_X_ The components in this mixture have been found to be noncarcinogenic by NTP, IARC, and OSHA.

SECTION 6 Reactivity Data

Stability:	Stable __X__	Unstable ______
Conditions to avoid:	NA	
Incompatibility:	Strong oxidizing materials	
Hazardous decomposition products:	Thermal decomposition may yield carbon monoxide and/or carbon dioxide.	
Hazardous polymerization:	May occur ______	Will not occur __X__

SECTION 7 Spill or Leak Procedures

Spill Response Procedures
Spill unlikely from aerosol cans. Leaking cans should be placed in plastic bag or open pail until pressure has dissipated.

Waste Disposal Method
Empty aerosol cans should not be punctured or incinerated; bury in land fill. Liquid should be incinerated or buried in land fill. Dispose of in accordance with local, state, and federal regulations.

Figure 11-5 (continued). This figure portrays the material safety data sheet for WD-40®.

SECTION 8 Special Handling Information

Ventilation	Sufficient to keep solvent vapor less than TLV.
Respiratory Protection	Advised when concentrations exceed the TLV.
Protective Gloves	Advised to prevent possible skin irritation.
Eye Protection	Approved eye protection to safeguard against potential eye contact, irritation, or injury.
Other Protective Equipment	None required.

SECTION 9 Special Precautions

Keep from sources of ignition. Avoid excessive inhalation of spray particles. Do not take internally. Do not puncture, incinerate, or store container above 120°F. Exposure to heat may cause bursting. Keep away from children.

SECTION 10 Transportation Data

Domestic Surface	
Description:	Consumer Commodity
Hazard Class:	ORM-D
Label Required:	Consumer Commodity (ORM-D)
Domestic Air	
Description:	Consumer Commodity (Flammable Gas-Aerosol products)
Hazard Class:	ORM-D
ID No:	NONE
Label Required:	Consumer Commodity (ORM-D-AIR)

SECTION 11 Regulatory Information

All ingredients for this product are listed on the TSCA inventory.

SARA Title III chemicals:	None
California Prop 65 chemicals:	None
CERCLA reportable quantity:	None
RCRA hazardous waste no:	D001 (Ignitable)

SIGNATURE: R. Miles TITLE: Technical Director

REVISION DATE: October 1993 SUPERSEDES: August 1992

NA = Not applicable NDA = No data available < = Less than > = More than

We believe the statements, technical information and recommendations contained herein are reliable. However, the data is provided without warranty, expressed or implied. It is the user's responsibility both to determine safe conditions for use of this product and assume loss, damage or expense, direct or consequential, arising from its use. Before using product, read label.

Figure 11-5 (continued). This figure portrays the material safety data sheet for WD-40®.

HAZARDOUS CHEMICAL LABELS AND LISTS

Under OSHA regulations, manufacturers, importers, and distributors of hazardous chemicals must label all products with information that identifies the specific hazards of the products. Employers may not remove these labels. If an employer transfers hazardous material into another container to be used by another employee for longer than one shift, the new container must also be labeled. Figure 11-6 shows two examples of product labels. Labels must include:

- Product name.
- Name, address, and phone number of the manufacturer, importer, or supplier.
- Hazards of the product including information such as:
    - Precautionary warning words, such as caution or warning.
    - Reactivity hazards of the product. For example, can the product be safely mixed with water?
    - Health hazards of the product, such as cancer-causing or respiratory irritant.
    - Target organs that might be affected by exposure, such as the lungs or kidneys.
    - Measures to protect the user, such as adequate ventilation or protective clothing.
    - Emergency first-aid information. For example, *wash exposed areas with water for 15 minutes*.

Information might be presented on the container in the form of a sign, symbol, or written word. Important warning words frequently used on labels include:

- Caution: Use with care. Workers are at some risk.
- Warning: The product presents more risk than one with a caution label.
- Danger: The most severe rating. The product presents a serious potential threat.

F

2 - Propanol

Fisher Chem AL Guide

For laboratory and manufacturing use only, not for drug, food, or household use.

Class 1B
4L

S77798

Isopropanol **UN1219**

WARNINGS! **FLAMMABLE FLASH POINT...59°F. HARMFUL IF INHALED. 20,000 ppm, IMMEDIATELY DANGEROUS TO LIFE AND HEALTH. CAUSES IRRITATION TO EYES, SKIN, AND MUCOUS MEMBRANES. IRRITANT AND ANESTHETIC. HARMFUL IF SWALLOWED. OVEREXPOSURE MAY CAUSE NARCOSIS, DEPRESSED RESPIRATION, ANEMIA, UREMIA, COMA, AND DEATH FROM RESPIRATORY PARALYSIS.**
TARGET ORGANS AFFECTED: Eyes, mucous membranes, skin, respiratory and central nervous systems. Do not breathe vapors. Keep container closed. Use only with adequate ventilation by providing local exhaust or process enclosure to meet permissible exposure limits or use NIOSH recommended respirators listed in the Material Safety Data Sheet. Keep away from heat, sparks, and open flame. Wash thoroughly after handling. Do not take internally. **FIRST AID - INHALATION -** Remove from exposure area to fresh air immediately.

SAFETY CODE

Goggles
Gloves
Apron

NFPA CODE

4
1 1

FisherScientific®

711 Forbes Avenue
Pittsburg, PA 15219-4785
(412) 562-8300

ACETONITRILE
CAS NO. 75-05-08 NA-1648 RQ
WARNING!
FLAMMABLE
MAY BE HARMFUL OR FATAL IF SWALLOWED, INHALED, OR ABSORBED THROUGH THE SKIN.
MAY BE IRRITATING TO THE SKIN, EYES, AND RESPIRATORY TRACT.
TOXIC EFFECTS MAY BE DELAYED.

Before using this product, read the MSDS which contains more detailed precautionary measures, handling instructions, and emergency procedures.

Keep away from heat, sparks, and flame. Avoid breathing vapor. Use with adequate ventilation. Avoid contact with eyes, skin, and clothing. If contact is unavoidable, wear protective clothing, face protection, and gloves. Wash thoroughly after handling and before eating, drinking, or smoking. Keep container closed.

FIRST AID:

If swallowed/ victim is conscious: Give 1-3 glasses of water or milk and INDUCE VOMITING. Do not induce vomiting with a semi-conscious or unconscious person. GET IMMEDIATE MEDICAL ATTENTION.

If in eyes: Flush immediately with plenty of water for at least 15 minutes. Eyelid should be held away from the eye to ensure thorough rinsing. Get medical attention if irritation persists.

If on skin: Wash exposed area thoroughly with soap and water. Remove contaminated clothing and shoes. Wash clothing and thoroughly clean shoes before reuse. GET MEDICAL ATTENTION.

If inhaled: Remove affected person from the source of exposure. If not breathing, administer CPR. If breathing is difficult, ensure a clear airway and oxygen may be given. GET IMMEDIATE MEDICAL ATTENTION.

Standard Oil Chemical Company
(216) 586-4141
Cleveland, Ohio, 44114-2375, U.S.A.

Figure 11-6. These two labels illustrate the information that must be included on product labels.

Special Labels

Although special labels are not required by the standard, employers may use them when hazardous chemicals are transferred from larger to smaller containers on the job site. These labels must not be removed or defaced because they provide important information. Figure 11-7 shows a typical label used for identifying hazardous materials with the *Hazardous Materials Identification System* (*HMIS*). The name of the product is listed and the appropriate boxes are marked under the headings:

- Target organs and effects
- Health hazards
- Physical hazards
- Route of entry

The label in Figure 11-7 has circles in front of health, flammability, reactivity, and protective equipment. These circles are filled in with a letter or number from the lists in the figure. Information from MSDSs, product labels, and Department of Transportation (*DOT*) or National Fire Protection Association (*NFPA*) labels are also used to fill out these special labels.

There may be other labels on a hazardous chemical container providing hazard information. The two most common labels are from the NFPA and the DOT.

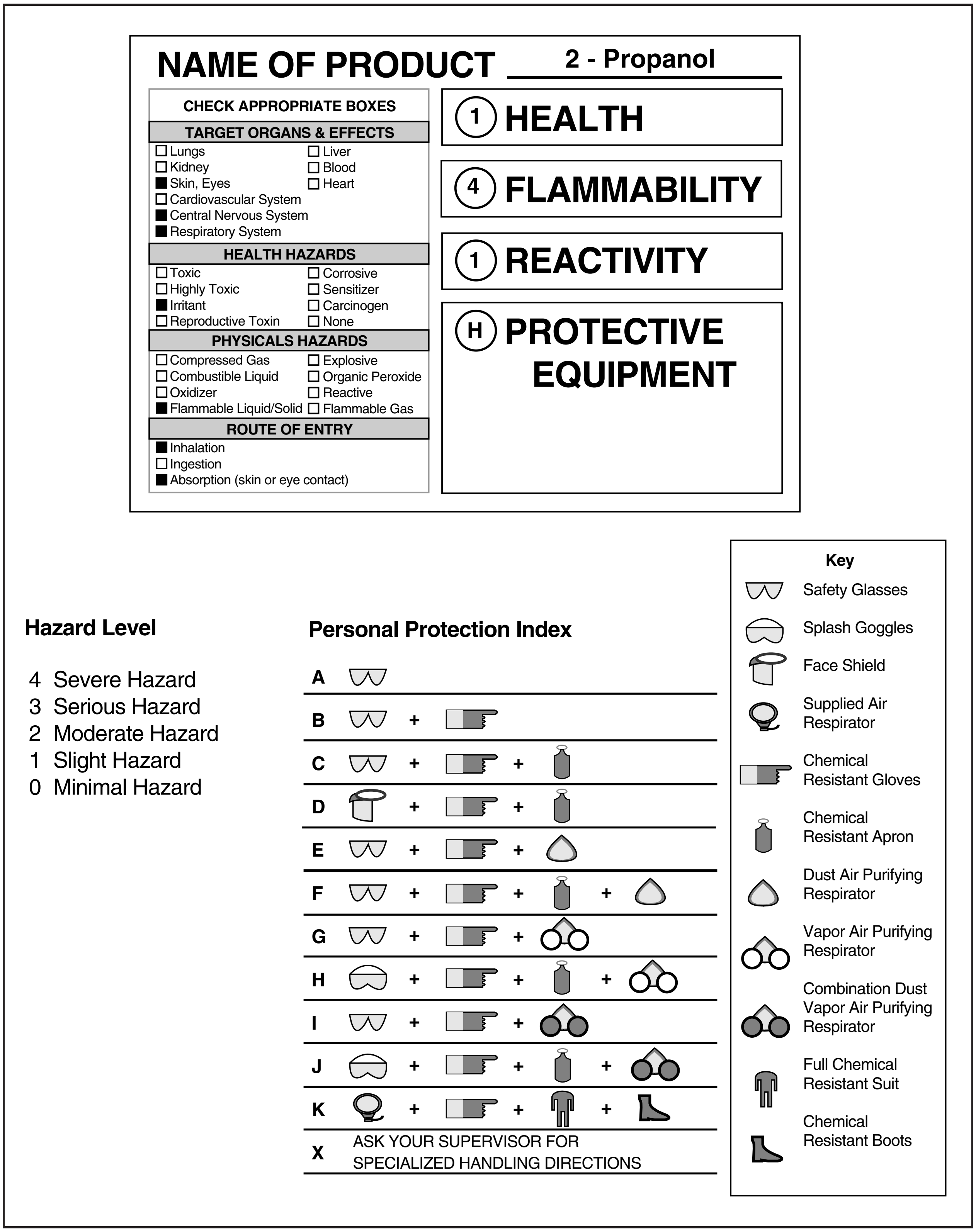


Figure 11-7. These are examples of an HMIS label with hazard and personal protection explanations.

National Fire Protection Association Labels

The NFPA label is a hazard system identification label developed to warn firefighters about potential chemical hazards in a fire. It's commonly used today and provides important information to the worker.

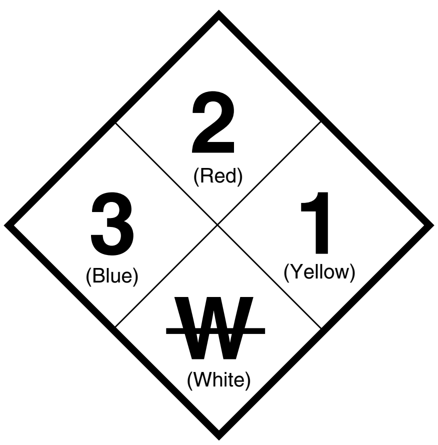
The NFPA label is a diamond containing four squares in different colors. The squares are red, blue, yellow, and white. The red, blue, and yellow squares contain a hazard rating, ranging from 0 to 4, that indicates the severity of the hazard. The white square is reserved for symbols representing special hazards.

Figure 11-8 shows an example of an NFPA label and identifies the following:

- Color code designations
- Hazard ratings meanings
- Special hazard symbols

Flammability Hazard - RED
4 - Below 70º F
3 - Below 100º F
2 - Between100º F and 200º F
1 - Above 200º F
0 - Will not burn

Health Hazard - BLUE
4 - Deadly
3 - Extreme danger
2 - Hazardous
1 - Slightly hazardous
0 - Normal



Reactivity Hazard - YELLOW
4 - May detonate
3 - Shock or heat may detonate
2 - Violent chemical changes
1 - Unstable if heated
0 - Stable

Special Hazard - WHITE
OXY - Oxidizer
COR - Corrosive
~~W~~ - Use no water
☢ - Radioactive

Figure 11-8. NFPA labels contain color codes and hazard information.

Table 11-2 is a more detailed explanation of the NFPA color codes and hazard rating information.

Note: An NFPA label does not cover chronic health effects. In addition, the names of the chemical, the product, and the manufacturer are not given.

Table 11-2. This table illustrates NFPA color codes and hazard rating information.

Health Hazard Color Code: **BLUE** Noted in the blue square Rated: 0 to 4 (4 = most dangerous level) **Type of Possible Injury**		**Flammability Hazard** Color Code: **Red** Noted in the red square Rated: 0 to 4 (4 = most dangerous level) **Susceptibility to Burning**		**Reactivity Hazard** Color Code: **Yellow** Noted in the yellow square Rated: 0 to 4 (4 = most dangerous level) **Susceptibility to Energy Release**	
4	Extremely Hazardous (deadly) - very short exposure can cause death or major long-term injury.	4	Extremely Flammable (below 73°F) - turns into a gas rapidly under normal conditions and burns easily.	4	Extremely Unstable (may detonate) - under normal conditions, this chemical may explode or react violently.
3	Highly Hazardous (extreme danger) - short exposure can cause serious temporary or possible long-term injury.	3	Highly Flammable (below 100°F) - liquid or solid can be ignited at almost any ordinary temperature.	3	Unstable (shock or heat may detonate or explode) - may react with water, or may need heating or another strong initiating source.
2	Moderately Hazardous (hazardous) - intense or continued exposure can cause temporary or possible long-term injury.	2	Moderately Combustible (between 100°F and 200°F) - must be heated somewhat or be in a very hot place before ignition can occur.	2	Unstable (violent chemical changes) - may react violently with water, or undergo violent chemical changes without exploding.
1	Slightly Hazardous (slightly hazardous) - exposure can cause irritation but only minor injury.	1	Slightly Combustible (above 200°F) - must be heated before ignition can occur.	1	Unstable if Heated - normally stable, but can become unstable when hot or under pressure. Reactions with water are not violent.
0	No Health Hazard (normal) - exposure under fire conditions would offer no hazard beyond that of ordinary combustibles.	0	Nonflammable or Noncombustible - will not burn.	0	Stable - normally stable, even in fire. Does not react with water.

Department of Transportation Labels

The DOT label is used on containers and cartons of hazardous materials or products that are shipped across state lines. These labels are in addition to those required by OSHA regulations. A DOT label contains three types of information: color, hazard word, and hazard symbol. Figure 11-9 shows the DOT label for a corrosive chemical. The combination of color, hazard word and hazard symbol gives a great deal of information about the hazardous material. However, the DOT label does not identify the product's name, manufacturer, or chemical contents.

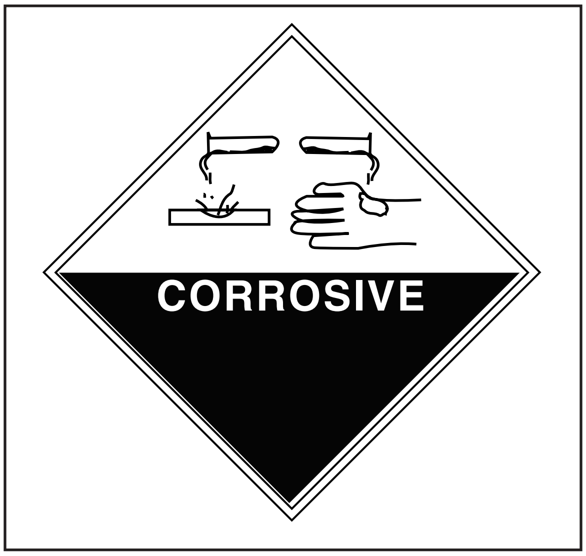


Figure 11-9. The DOT label for a corrosive chemical contains three types of information.

Table 11-3 lists the color-coded backgrounds and hazard words used on DOT labels. Figure 11-10 shows the different hazard symbols used on the label.

When shipping hazardous materials, the severity of a hazard may be indicated on the shipping container. Hazards are divided into three packing groups:

Packing Group I	-	Great Danger
Packing Group II	-	Medium Danger
Packing Group III	-	Minor Danger

Table 11-3. The color-coded backgrounds and hazard words found on DOT labels help you identify hazardous materials or products.

Color Codes	Hazard Words
Orange	Explosive Blasting agent
Red	Flammable Combustible
Green	Nonflammable
Yellow	Oxidizer Oxygen Organic peroxide
White with red stripes	Flammable solids
Yellow and white	Radioactive
White and black	Corrosive
White	Poison Chlorine
Blue	Dangerous when wet
Special	Biological agent

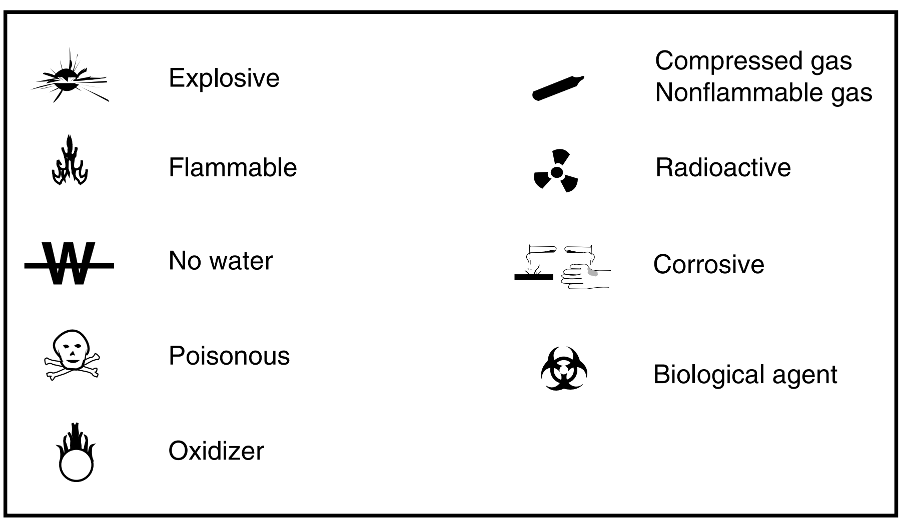


Figure 11-10. Hazard symbols used on a DOT label aid you in identifying the hazard.

CHEMICALS USED IN CONSTRUCTION

There are many hazardous chemicals used in construction to which you can be exposed to. Most of these chemicals are grouped into general categories of similar hazards. The most common categories of hazardous chemicals found on construction sites include:

- Acids, bases, and alkalis
- Adhesives and sealants
- Cleaners
- Concrete
- Fuels
- Solvents
- Wood

Acids, Bases, and Alkalis

Acids and bases (caustics) come in various forms—gases, liquids, and solids. Examples of common acids include sulfuric acid, hydrochloric acid, muriatic acid (hydrochloric acid), and nitric acid. Commonly used bases (caustics) are lye (sodium hydroxide) and potash (potassium hydroxide). Both acids and bases can easily damage the skin and eyes. The seriousness of the damage depends on the strength of the chemical, length of contact, and actions taken.

Both acids and bases can be corrosive and can damage whatever material they touch. The more concentrated the chemical, the more dangerous it can be. Vinegar is a mild form of acetic acid and can be swallowed or rubbed on the skin with no damage. However, a concentrated solution of acetic acid causes serious burns.

Different acids react differently when they contact skin. Following are some examples:

- Mixing sulfuric acid with water produces heat. If sulfuric acid contacts skin, it reacts with the skin's moisture and burns.

- If hydrofluoric acid spills on the skin, you may not notice it. But hours later, the hydrofluoric acid will have worked its way through the skin and into the muscle tissue, causing deep burns. These burns are painful and take a long time to heal. If serious enough, they can cause death.

- Acids can damage the respiratory system when inhaled. Some acids in a gas or vapor form react with the moisture in the nose and throat causing irritation or tissue damage. Acetic and nitric acid vapors quickly penetrate the lungs causing serious damage.

In general, bases feel slippery or soapy. Soap is made from a mixture of a base (lye) and animal fat. Concentrated bases dissolve tissue easily and can cause severe skin damage on contact. Concentrated caustic gases, like ammonia, can damage the skin, eyes, nose, mouth, and lungs. Even dry powder forms of bases can cause damage when absorbed or inhaled, because they react with the moisture in the skin, eyes, and respiratory tract.

Always follow these rules when working with acids and bases:

- Know what chemicals are being worked with and how strong or concentrated they are.

- Use PPE, as required.

- In case of skin or eye contact, flush with cool water for at least 15 minutes. Do not rub skin or eyes.

- When mixing acids and water, always add the acid to the water to prevent splatter.

- Keep acids and bases apart. Store them separately and cleanup spills promptly. Acid and bases react, often violently, when mixed.

Cement and mortar are alkali compounds in their wet or dry form. As dust and powder, they can damage the skin and eyes when they react with moisture in the body. Cement and mortar also can cause allergic reactions in people who become sensitive to them.

Adhesives and Sealants

All adhesives and sealants have some type of hazard warning on the label. Because people often use them at home and on the job, warnings are taken lightly or ignored. However, adhesives and sealants are toxic because of their chemically reactive ingredients, or because of the solvent base that permits them to be applied more easily.

Adhesives or sealants that contain solvents may be flammable. Other types of adhesives, such as caulking or wood glue, may irritate eyes and skin. When working with any glue, avoid eye and skin contact. If the label says the adhesive is flammable, use and store it away from sources of ignition.

Epoxies contain epoxy amine resins and polyamide hardeners, each of which sensitizes skin and irritates the respiratory tract. Overexposure to epoxies can cause dizziness, drowsiness, nausea, and vomiting. Extreme or prolonged exposure can damage the kidneys and liver.

Flooring adhesives can contain acrylics that irritate the skin and cause nausea, vomiting, headache, weakness, asphyxia, and death. Other adhesives or sealants contain coal tar derivatives that are suspected of causing cancer. Avoid prolonged breathing of vapors or skin contact.

Cleaners

Cleaners contain acids, alkalis, aromatics, surfactants, petroleum products, ammonia, and hypochlorite. These ingredients cause cleaners to be irritating, and they can be harmful if swallowed or inhaled. Hazards from cleaners include:

- Health hazards (eye, nose, throat, skin, and lung irritation)
- Fire (some cleaners burn easily)
- Corrosive (cause severe skin damage)

Because of the variety of cleaning materials in use, there are many signs and symptoms of overexposure. Therefore, it is important for workers to read the MSDS of each product to learn its specific signs and symptoms.

Many industrial cleaners are products commonly found in the home, so you may underestimate the hazards they pose. You can protect yourself from these chemicals by taking the following actions:

- Read the labels and follow recommended precautions.
- Wear gloves and eye protection.
- Wash hands and face thoroughly before eating, drinking, or smoking.
- Do not inhale vapors or mists.
- Do not eat, drink, or smoke where vapors, mists, or dust are in the air.

Do not mix cleaning chemicals together unless specifically told to do so by a technical expert. Some chemicals can become deadly when mixed. For example, when bleach and ammonia or bleach and a drain cleaner are mixed, chlorine gas is produced. Chlorine gas is toxic and potentially explosive.

Concrete

Cement and lime, components of concrete, can cause adverse health effects such as skin irritation. The more lime in the cement, the more irritating it is to the skin. Cement that is even slightly moist can cause the skin to become hard, dry, and thick. The skin often cracks and can form ulcers. When water is added to cement, it produces heat which can also irritate and burn the skin. Cement dust also irritates the eyes, nose, and mouth. Use proper personal hygiene and the appropriate PPE to protect against cement's irritating alkaline effects.

Once concrete has cured or hardened, the health hazard to workers is dust which can damage the respiratory system. The dust is created when cutting concrete. Always try to use water to control the generation of dust. Also wear the appropriate respiratory protection to protect the lungs from the dust.

Fuels

The primary hazard posed by fuels is fire. Fuels are either flammable or combustible and should be handled with care. Follow these steps when handling fuel:

- Know the location of fire extinguishers, fire alarms, and evacuation procedures when dispensing or using fuels.
- Always store and transport fuel in approved, self-closing safety containers.
- Store gasoline and kerosene in properly marked containers. Never use kerosene containers for the transport or storage of gasoline.
- Properly ground and bond the container when filling portable containers with flammable materials to prevent ignition caused by static electricity.
- Use a bonding clamp to bond and ground containers when dispensing fuels.
- Check that spark-arrestors are in place when using portable containers.
- Remember, if a fuel is spilled, the vapors can travel some distance to an ignition source resulting in fire or an explosion.
- Do **not** store, use, or dispense fuel near arc welding or open flames.
- Do **not** pour waste fuel and flammable liquids down drains. See the MSDS for proper disposal procedures.

Excessive skin contact with fuels results in dermatitis. Fuels can enter the body through the skin and, over a long period, break down the fatty tissues and possibly build up in the body. Excessive inhalation of fuels can cause central nervous system depression and aggravate any existing respiratory disease. Leukemia, a blood disorder that usually causes death, is a potential side effect of chronic (long-term) exposure to fuels. Ingestion of fuels can cause poisoning and possible lung damage if aspirated into the lungs when ingested. Acute exposure to fuels can result in skin, lung, and respiratory tract irritation.

You can protect yourself from these chemicals by reading the labels and following the recommended precautions. Wear gloves and eye protection and avoid inhaling the vapors and mists. Wash hands and face thoroughly before eating, drinking, or smoking. Specific emergency first-aid procedures are given in the MSDS for fuels. In general, if fuel gets into your eyes, flush with clean running water for at least 15 minutes and then seek medical attention. If it gets on your skin, wash the area of contact.

Solvents

A solvent is a substance, usually a liquid, that can dissolve another substance. In construction, the most commonly used solvents are cleaners, degreasers, and thinners. There are two main classes of solvents:

1. Aqueous solvents (water-based), such as acids, alkalis, and detergents.
2. Organic solvents (carbon-containing), such as acetone, benzene, mineral spirits, toluene, trichloroethylene, and turpentine.

The two most common ways solvents enter the body are inhalation (breathing) or absorption (skin contact). Exposure to water-based solvents results in health effects such as dermatitis and irritation. Excessive exposure to aqueous solvents in the form of mists can cause throat irritation or bronchitis.

Organic solvents cause more serious health effects, depending on the solvent and the exposure level. All organic solvents affect the central nervous system by acting as depressants or anesthetics. Effects can range from dizziness and headaches to respiratory arrest and death. Workers exposed to organic solvents can also experience:

- Nose, throat, eye, and lung irritation
- Damage to the liver, blood, kidneys, and digestive system

Upon contact with the skin, an organic solvent will dissolve the oils in the skin. The skin becomes dry and irritated, producing cracking and skin rashes. If a solvent penetrates the skin, it enters the bloodstream and can attack the central nervous system and other body organs. Like all chemicals, the effect a solvent has upon a worker depends on several factors:

- The chemical's toxicity
- The length of exposure
- The sensitivity level of the body
- The concentration of the solvent

You can protect yourself from solvent hazards by following these simple rules:

- Know what chemicals are being used.
- Wear appropriate PPE, such as gloves, safety glasses, and respirators to prevent contact with the skin, eyes, and lungs.
- Ensure the work area has plenty of fresh air.
- Avoid skin contact with solvents.
- Wash with plenty of soap and water if skin contacts the solvent.
- Flush with running water for at least 15 minutes if a solvent splashes into your eye. Get medical help.

Wood

The primary concern regarding wood is pressure-treated lumber. The pressure treatment process uses inorganic arsenic, copper, zinc, a pesticide, or a combination of these, sometimes called *CCA* (chromated copper arsenate) to protect the lumber from decay and insect attack. The chemicals are forced deeply into the wood where they remain for a long time. As a result, treated wood, whether fresh from the lumber yard or found in an existing structure, can pose health hazards if not handled properly.

Avoid inhalation of sawdust from treated wood. Wear a dust mask when cutting, routing, sanding, or working with treated wood. Whenever possible, perform these operations outdoors to avoid indoor accumulations of airborne sawdust from treated wood. Keep bystanders, children, and pets from walking in the collected sawdust.

Some treated woods may appear damp and have chemical residue on the surface. Use gloves when handling freshly treated lumber and especially the sawdust from freshly treated wood.

Clean up all wood construction debris and dispose in ordinary trash collection. Do not burn pressure treated scraps in home stoves, fireplaces, or open fires, because the chemicals may become part of the smoke and ashes. Treated wood may be burned in commercial and industrial incinerators or boilers, according to state and federal regulations. Do not use treated wood in circumstances where the wood will come in direct contact with food or with public drinking water sources.

Acute allergic reactions have been reported following contact with mahogany, birch, beech, and other untreated woods. These reactions include hives, respiratory tract irritation, and general swelling. To reduce the likelihood of such a reaction, use good personal hygiene. Wash hands and face thoroughly. Take meals and breaks away from the work area. Upon completion of work, remove work clothing and launder separately from non-work clothing. Shower thoroughly to remove any material in contact with skin.

TYPICAL CONSTRUCTION HAZARDS

Table 11-4 provides a review of the typical hazardous substances used in construction. Hazardous substances are arranged by classes with information on each class summarized in the table. The table covers the following areas:

- Class – group of similar substances used for the same purpose, such as abrasives or fuels.
- Examples – identifies examples of the commonly used substances in each class.

- Routes of Entry – identifies how a particular substance enters the body. Routes of entry include:

    - Inhalation (breathing)
    - Ingestion (swallowing)
    - Absorption (skin)
    - Skin or eye contact

- Physical Hazards – describes the hazards a substance holds for you, such as explosive, flammable, or compressed gas.

- Health Hazards – explains the health effects a substance may have if workers are exposed to it. Examples include irritating to skin, cancer-causing and infectious.

- Target Organs – identifies which organs in the body are affected by exposure to the hazardous substance.

- How Detected – a general guide to recognizing this group of substances. For example, fuels are usually liquids that have a characteristic odor that is easily recognized.

- Types of Protection – provides some general guidelines on protecting yourself from exposure, such as respirators and ventilation to protect the lungs. It notes when a substance can be transferred from the air or hands to food, drink, or smoking materials.

Use this table as a general review of hazardous chemical information. **Always** review the MSDSs for hazardous chemicals used on the job site, especially when a chemical is used for the first time. The MSDS may differ from the information in the table. Follow the MSDS.

There are many hazardous chemicals used in construction. Other construction trades are exposed to a few of these chemicals. However, construction laborers may be exposed to all of them.

Table 11-4. This table lists hazardous substances used in construction.

Class	Examples	Entry Routes	Physical Hazards	Health Hazards	Target Organs	How Detected	Types of Protection
Abrasives	Abrasive belts, disks, and wheels; silica, sandblasting	Inhalation, Skin and eye contact	Physical injury to skin and eyes	Damage to skin, eyes, and lungs. Chronic lung disease. Cancer, if removing nickel or chrome alloy metals or asbestos coatings.	Skin, eyes, lungs	Airborne dust	Ventilation, respirators, eye protection, faceshields, gloves
Adhesives	Caulking, epoxy, plastic cement, flooring adhesives, super glue, urethane sealant, white glue	Inhalation Ingestion Skin and eye contact	Combustible Flammable	Damage to skin, eyes, and lungs. Skin sensitizers. Nervous system effects. Mucous membrane irritant. Cancer, toxic.	Lungs, kidneys, liver, eyes, skin, central nervous system, peripheral nervous system	Odor. Container. Usually liquids.	Ventilation, respirators, eye protection, gloves, personal hygiene
Asbestos	Insulation on pipe, beams, ceilings, etc.	Inhalation	None	Damage to lungs. Cancer.	Lungs	Unknown. Insulation, usually old and friable.	Training required by OSHA regulations. Contact a foreman if you suspect asbestos is present.
Asphalt products	Asphalt, tar, creosote, cutback, pitch	Inhalation Ingestion Skin and eye contact	Combustible Flammable	Damage to skin, eyes, and lungs. Cancer. Irritant. Toxic.	Lungs, liver, kidneys, eyes, skin, brain, bladder, central nervous system	Odor. Fumes. May be hot. Solid or liquid.	Ventilation, respirators. eye protection, gloves, personal hygiene, coveralls
Biological materials	Sewage, fecal matter, tetanus, rabies	Inhalation Ingestion Skin contact	None	Localized skin infections. Infectious diseases.	Skin, body in general depending upon the specific disease.	Work area. Animals when site cleaning.	Personal hygiene, gloves, respirators, tetanus immunization
Cleaners	Bleach, drain and glass cleaner, germicide, metal polish, stain removers, cleaning sprays	Inhalation Ingestion Skin and eye contact	Flammable Reactive	Irritant to eyes, nose, throat, skin, and lungs. Corrosive. Damage to skin, eyes, and lungs.	Skin, eyes, lungs	Odor. Container. Solids or liquids.	Personal hygiene, gloves, eye protection, ventilation, respirators
Coatings	Waterproofing, anti-corrosion, epoxies, polish, floor finish, varnish, waxes, cleaning spray, wood preservatives	Inhalation Ingestion Skin and eye contact Skin absorption	Flammable Combustible	Irritant to eyes, skin, nose, lungs, and throat. Toxic. Cancer. Nervous system. Damage to reproductive organs. Reduced fertility. Birth defects. Damage to bone marrow.	Skin, eyes, lungs, nervous system, reproductive organs, blood	Odor. Container. Liquids.	Personal hygiene, gloves, ventilation, eye protection, respirators

Table 11-4 (cont.). This table lists hazardous substances used in construction.

Class	Examples	Entry Routes	Physical Hazards	Health Hazards	Target Organs	How Detected	Types of Protection
Fuels	Diesel fuel, gasoline, kerosene, propane	Inhalation Skin and eye contact	Flammable Combustible	Damage to skin, eyes and lungs. Toxic-ingestion. Central nervous system. Irritant. Cancer	Skin, eyes, lungs, central nervous system, blood	Odor. Liquids. Appearance.	Personal hygiene, gloves. ventilation, eye protection. Approved containers. Bond and ground when filling.
Gases, compressed	Acetylene, oxygen, hydrogen, freon, ammonia propane, LPG, nitrogen	Inhalation Skin and eye contact	Flammable Combustible Oxidizer Compressed gas	Corrosive. Irritant. Damage to eyes and lungs. Asphyxiant. Heart attacks (freon). Toxic	Skin, eyes, lungs central nervous system, heart	Odor (some). Compressed gas cylinder. Label on cylinder.	Handle, use, and store properly. Do not breathe gases. Use proper connections, equipment, and procedures.
Gases, noncom-pressed	Carbon monoxide, nitrogen, hydrogen sulfide, carbon dioxide	Inhalation	Flammable	Asphyxiant. Toxic to highly toxic.	Lungs, blood, central nervous system	Odor (hydrogen sulfide-rotten eggs). Others-none	Check confined spaces for oxygen, other gases, and vapors before entering. Ventilation.
Insulation (non-asbestos)	Foam, graphite, fiberglass, rock wool vermiculite, kaowool, inswool	Inhalation Skin and eye contact	None	Irritant. Damage to the lungs and eyes. Skin irritant.	Skin, eyes, lungs	Package. Application area. Fibrous solids or foams.	Ventilation, gloves, long sleeve shirts, respirators, coveralls, eye protection. Personal hygiene including showers.
Lubricants	Oils, greases, cutting oils	Inhalation. Skin and eye contact	Combustible Flammable	Lung, skin, and eye irritant. Cancer.	Skin, eyes, lungs	Appearance. Container. Liquid is usually thick.	Gloves, eye protection, ventilation. Personal hygiene.
Masonry	Brick, concrete, lime, muriatic acid, mortar, refractory brick, sand (silica), gunite refractory	Inhalation. Skin and eye contact	None	Skin, eye, and lung irritation. Damage to lungs. Corrosive to lungs, skin, eyes, and mucous membranes (muriatic acid).	Skin, eyes, lungs	Physical appear-ance. Dust when cutting, gunning, etc. Solids except muriatic acid.	Gloves, eye protection, ventilation, respirators. Personal hygiene. Chemical goggles when using acids
Metals	Cadmium, galvanized metal, babbitt metal, lead, nickel, manganese, zinc, chromium	Inhalation Ingestion	None as a solid metal. Many metal dusts are explosive	Irritating to the lungs. Damage to the lungs. Cancer. Toxic to highly toxic (cadmium fume and dust).	Lungs, blood, central nervous system	Appearance. Solids. Often coated on other metals or alloyed with other metals.	Personal hygiene. Eye protection, ventilation, respirators
Paint products	Enamel, latex, thinners, lacquers, primers, cleaners, strippers, removers, turpentine	Inhalation Skin and eye contact	Combustible Flammable	Due to wide range of hazardous materials in the products, health hazards range from skin irritations to coma or convulsions to cancer. Read MSDS for each product.	All body organs are possible target organs. See specific product's MSDS	Appearance. Odor. Liquid or paste.	Ventilation, respirators, eye protection, gloves, protective clothing. Personal hygiene.

Table 11-4 (cont.). This table lists hazardous substances used in construction.

Class	Examples	Entry Routes	Physical Hazards	Health Hazards	Target Organs	How Detected	Types of Protection
Pesticides, herbicides, fungicides	Baygon, DDVP, diazinon, parathion, many others	Inhalation Ingestion Skin absorption	Combustible Flammable Explosive	Toxic to highly toxic. Irritant.	Lungs, blood, central nervous system. Penetrates the skin.	Container should have EPA label on it. Liquids or powders.	Personal hygiene. Respirators, ventilation, protective clothing, eye protection. Use extra care when diluting/ mixing concentrates.
Radioactive materials and lasers	Lasers, soil, or asphalt density instruments (radioactive source)	Eye and skin contact Inhalation	None	Lasers - damage to the eyes and skin. Radioactive - damage to the skin, lungs, and all internal organs. Cancer.	Skin, eyes, lungs, internal organs.	Warning labels on instruments using lasers or radioactive materials.	Do not handle, use, or service equipment unless trained to do so. Avoid eye exposure to laser beam and use proper eye protection when needed.
Solvents	Acetone, ketone, hexane, toluene, xylene, mineral spirits, methyl ethyl alcohol, chlorinated solvents	Inhalation Skin and eye contact Ingestion	Combustible Flammable	Toxic. Cancer. Irritant. Damage to the skin.	Skin, eyes, lungs, liver, central nervous system, kidneys. Peripheral neuropathy. Mucous membranes.	Odor. Liquids.	Ventilation, respirators, gloves, protective clothing, eye protection. Personal hygiene.
Welding, soldering, brazing, and cutting	Electrodes, solders, fluxes, lead, metals, compressed gas. See listing above	Inhalation Skin and eye contact	Compressed gases. Electrical and thermal burns.	Toxic to highly toxic fumes. Damage to eyes, skin, and lungs. Cancer. Irritant.	Skin, eyes, lungs, liver, central nervous system, blood.	Appearance. Solids. Pastes (fluxes).	Ventilation, special eye protection, respirators, protective clothing. Personal hygiene.
Wood products	Sawdust, pressure treated lumber, beech, mahogany	Inhalation Ingestion Skin contact Skin absorption	Combustible	Sensitization. Allergic reactions to some woods. Toxic.	Skin and lungs. Caution: A number of body organs may be affected by the products used to treat wood. Avoid exposure to sawdust when cutting this wood.	Appearance. Pressure treated wood may have color when it is fresh.	Ventilation, gloves, eye protection, respirators. Personal hygiene.

Note: This table is only a general overview of typical hazardous substances used in construction. The substances listed here may not be the same as you use on the job site. Therefore, you should review the MSDS for each product you use, especially the first time you use it.

SECTION 11 - ASSIGNMENT SHEET

1. Define the following terms or words:

   Administrative controls ______________________________

   ____

   ____

   Engineering controls ______________________________

   ____

   ____

   Substitution ______________________________

   ____

   ____

   ____

   Time weighted average ______________________________

   ____

   ____

2. Identify the following acronyms:

   ACGIH ______________________________

   ____

   DOT ______________________________

   IDLH ______________________________

   MSDS ______________________________

   NFPA ______________________________

   ____

   NIOSH ______________________________

   ____

   PEL ______________________________

   TWA ______________________________

3. List the requirements of the Hazard Communication Standard's written program.

4. List the basic information that must be covered in the employer's training program for hazard communication.

5. List the information an employer must provide each employee.

6. List exposure control measures that protect workers from exposure.

7. Demonstrate how to use MSDSs by answering the following questions. (Use Figure 11-5 Sample MSDS)

   a. What is the name of the product? ______________________

   b. List the hazardous components of this product.

   ____

   ____

   c. Is this product lighter than air?

   ______ Yes ______ No

   d. What is the appearance and odor of this product? ______________

   e. What is the flash point of this product? ______________________

   f. Is this product flammable or combustible? ____________________

   g. What is the extinguishing media for this product? ______________

   h. Does this product contain cancer-causing components?

   ______ Yes ______ No

   i. Is respiratory protection required while using this product?

   ______ Yes ______ No

   j. What other PPE is to be used with this product? ______________

   ____

   ____

   k. What special precautions should be taken when using this product?

   ____

   ____

   ____

   l. When was this MSDS revised? ____________________________

   m. What is the emergency phone number for this product?

   ____

   n. Is emergency and first-aid information given?

   ______ Yes ______ No

8. List the information that must be given on a typical label.

9. List the three basic types of labeling systems.

10. Demonstrate how to read a label by answering the following questions. (Use either label in Figure 11-6.)

    a. What is the name of the product?

    b. Who makes it?

    c. What is the physical hazard from this product?

    d. What are the health hazards?

    e. What are the target organs?

    f. What are the safe handling recommendations?

    g. What measures are to be used to limit worker exposure?

h. What is the first-aid information given?

____

____

11. Complete the following questions using the chart. The chart describes a worker's exposure during a single working shift on a hazardous waste job site.

What is this worker's TWA for this particular day?

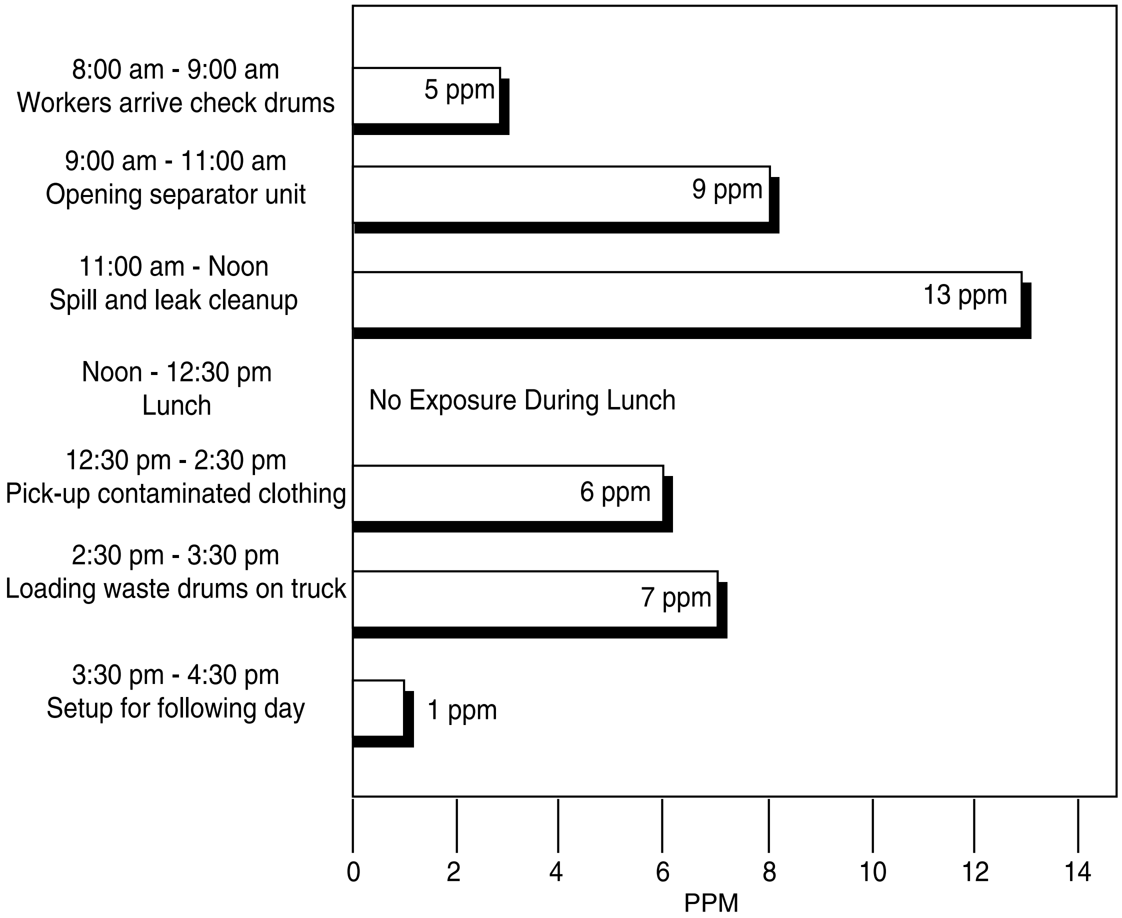
____

Identify the worker's exposure if the PEL for this chemical is 5 ppm?

____

Identify the worker's exposure if the PEL for this chemical is 9 ppm?

____



Section

Appendix

ASBESTOS ABATEMENT WORKER REFRESHER

Title

A P P E N D I X

ACCESSING OSHA

INTRODUCTION

OSHA and OSHA information may be accessed in one of three ways, depending upon the need:

1. OSHA emergency hot line
2. OSHA web site
3. OSHA publications

OSHA EMERGENCY HOT LINE

OSHA provides a free hot line for reporting workplace safety or health emergencies and hazards that are life threatening. The service provides a 24-hour point of contact so that situations of imminent danger on the job can be reported to OSHA as soon as possible. The toll-free, 24-hour **emergency** telephone number is 1-800-321-OSHA.

Two kinds of service are available to assist callers to the OSHA hot line. The type of service will depend upon the time of the initiating call—daytime or after-hours.

Daytime Calls

For telephone calls received during normal working hours, the representative answering the call requests the following:

- Caller's name (optional)
- Daytime telephone number (also optional)
- Zip code (required)

The caller is asked to hold while the representative determines the appropriate area office and then transfers the call to that office. Normal working hours are 8 a.m. to 4:30 p.m. local time, Monday through Friday.

After-Hours Calls

After normal working hours are 4:30 p.m. to 8 a.m. local time, Monday through Friday, all day Saturday, Sunday and during official government holidays. Calls received during this time request the same information as daytime calls, with an additional request for the best time for a callback.

OSHA WEB SITE

The OSHA web site is a valuable resource for information on OSHA, regulations, events, etc., and is found at **www.osha.gov**. In particular, the site contains the "OSHA Workers' Page." This web page will guide you through the process of filing a complaint on-line. It can be found at:

www.osha.gov/as/opa/worker/index.html

To access the on-line complaint form directly, go to:

www.osha.gov/as/opa/worker/eComplaintForm.html

You can complete the form on-line and send it from your computer. Or you can print the form, fill it out, and fax or mail it. Your computer must have Adobe Acrobat Reader to view and print this form. If it does not, the "OSHA Workers' Page" contains a link that will allow you to download the program for free.

It is important to note that on-line filing is **not** to be used for emergencies or hazards that are life threatening. In these situations contact your local OSHA regional office or call the hot line number 1-800-321-OSHA.

OSHA PUBLICATIONS

OSHA publications and information are available to the public. Many publications can be downloaded free from the web site, while others can be purchased from the U.S. Government Printing Office (GPO).

The OSHA CD-ROM is available through the GPO and contains the following publications:

- Complete text of all OSHA standards, including variances, interpretation of standards, and the preamble for OSHA 1910.1000, which contains the permissible workplace exposure limits.
- Chemical Information Manual.
- Field Operation Manual.
- OSHA Technical Manual.

To get a yearly subscription to the OSHA CD-ROM use order # 729-013-00000-5. The address and telephone number are:

SUPERINTENDENT OF DOCUMENTS
U.S. Government Printing Office
710 North Capitol Street, N.W.
Washington, D.C. 20402
Phone: (202) 512-1800

APPENDIX B
OSHA REGIONAL OFFICES

OSHA Region I
(CT, MA, ME, NH, RI, VT)
JFK Building
Room E340
Boston, MA 02203
Telephone (617) 565-9860

OSHA Region II
(NJ, NY, PR*, VI*)
201 Varick Street
Room 670
New York, NY 10014
Telephone (212) 337-2378

OSHA Region III
(DC*, DE, MD, PA, VA, WV)
The Curtis Center - Suite 740 West
170 S. Independence Mall West
Philadelphia, PA 19106-3309
Telephone (215) 861-4900

OSHA Region IV
(AL, FL, GA, KY, MS, NC, SC, TN)
61 Forsyth St. SW
Atlanta, GA 30303
Telephone (404) 562-2300

OSHA Region V
(IL, IN, MI, MN, OH, WI)
230 South Dearborn Street
Room 3244
Chicago, IL 60604
Telephone (312) 353-2220

OSHA Region VI
(AR, LA, NM, OK, TX)
525 Griffin Street
Room 602
Dallas, TX 75202
Telephone (214) 767-4731

OSHA Region VII
(IA, KS, MO, NE)
City Center Square
1100 Main Street, Suite 800
Kansas City, MO 64105
Telephone: (816) 426-5861

OSHA Region VIII
(CO, MT, ND, SD, UT, WY)
1999 Broadway
Suite 1690
Denver, CO 80202-5716
Telephone (303) 391-5858

OSHA Region IX
(AS*, AZ, CA, GU*, HI, NV, TT*)
71 Stevenson Street
Room 420
San Francisco, CA 94105
Telephone (415) 975-4310

OSHA Region X
(AK, ID, OR, WA)
1111 Third Avenue
Suite 715
Seattle, WA 98101-3212
Telephone (206) 553-5930

(Updated June 2000)

Section

Regulations

ASBESTOS ABATEMENT WORKER REFRESHER

Title

29 CFR 1926.1101

REGULATIONS

Subpart Z – Toxic and Hazardous Substances
29 CFR 1926.1101 – Asbestos

(a) Scope and application.

This section regulates asbestos exposure in all work as defined in 29 CFR 1910.12(b), including but not limited to the following:

(1) Demolition or salvage of structures where asbestos is present;

(2) Removal or encapsulation of materials containing asbestos;

(3) Construction, alteration, repair, maintenance, or renovation of structures, substrates, or portions thereof, that contain asbestos;

(4) Installation of products containing asbestos;

(5) Asbestos spill/emergency cleanup; and

(6) Transportation, disposal, storage, containment of and housekeeping activities involving asbestos or products containing asbestos, on the site or location at which construction activities are performed.

(7) Coverage under this standard shall be based on the nature of the work operation involving asbestos exposure.

(8) This section does not apply to asbestos-containing asphalt roof coatings, cements and mastics.

(b) Definitions.

"Aggressive method" means removal or disturbance of building material by sanding, abrading, grinding or other method that breaks, crumbles, or disintegrates intact ACM.

"Amended water" means water to which surfactant (wetting agent) has been added to increase the ability of the liquid to penetrate ACM.

"Asbestos" includes chrysotile, amosite, crocidolite, tremolite asbestos, anthophyllite asbestos, actinolite asbestos, and any of these minerals that has been chemically treated and/or altered. For purposes of this standard, "asbestos" includes PACM, as defined below.

"Asbestos-containing material (ACM)", means any material containing more than one percent asbestos.

"Assistant Secretary" means the Assistant Secretary of Labor for Occupational Safety and Health, U.S. Department of Labor, or designee.

"Authorized person" means any person authorized by the employer and required by work duties to be present in regulated areas.

"Building/facility owner" is the legal entity, including a lessee, which exercises control over management and record keeping functions relating to a building and/or facility in which activities covered by this standard take place.

"Certified Industrial Hygienist (CIH)" means one certified in the practice of industrial hygiene by the American Board of Industrial Hygiene.

"Class I asbestos work" means activities involving the removal of TSI and surfacing ACM and PACM.

"Class II asbestos work" means activities involving the removal of ACM which is not thermal system insulation or surfacing material. This includes, but is not limited to, the removal of asbestos-containing wallboard, floor tile and sheeting, roofing and siding shingles, and construction mastics.

"Class III asbestos work" means repair and maintenance operations, where "ACM", including TSI and surfacing ACM and PACM, is likely to be disturbed.

"Class IV asbestos work" means maintenance and custodial activities during which employees contact but do not disturb ACM or PACM and activities to clean up dust, waste and debris resulting from Class I, II, and III activities.

"Clean room" means an uncontaminated room having facilities for the storage of employees' street clothing and uncontaminated materials and equipment.

"Closely resemble" means that the major workplace conditions which have contributed to the levels of historic asbestos exposure, are no more protective than conditions of the current workplace.

"Competent person" means, in addition to the definition in 29 CFR 1926.32 (f), one who is capable of identifying existing asbestos hazards in the workplace and selecting the appropriate control strategy for asbestos exposure, who has the authority to take prompt corrective measures to eliminate them, as specified in 29 CFR 1926.32(f): in addition, for Class I and Class II work who is specially trained in a training course which meets the criteria of

EPA's Model Accreditation Plan (40 CFR 763) for supervisor, or its equivalent and, for Class III and Class IV work, who is trained in a manner consistent with EPA requirements for training of local education agency maintenance and custodial staff as set forth at 40 CFR 763.92 (a)(2).

"Critical barrier" means one or more layers of plastic sealed over all openings into a work area or any other similarly placed physical barrier sufficient to prevent airborne asbestos in a work area from migrating to an adjacent area.

"Decontamination area" means an enclosed area adjacent and connected to the regulated area and consisting of an equipment room, shower area, and clean room, which is used for the decontamination of workers, materials, and equipment that are contaminated with asbestos.

"Demolition" means the wrecking or taking out of any load-supporting structural member and any related razing, removing, or stripping of asbestos products.

"Director" means the Director, National Institute for Occupational Safety and Health, U.S. Department of Health and Human Services, or designee.

"Disturbance" means activities that disrupt the matrix of ACM or PACM, crumble or pulverize ACM or PACM, or generate visible debris from ACM or PACM. Disturbance includes cutting away small amounts of ACM and PACM, no greater than the amount which can be contained in one standard sized glove bag or waste bag in order to access a building component. In no event shall the amount of ACM or PACM so disturbed exceed that which can be contained in one glove bag or waste bag which shall not exceed 60 inches in length and width.

"Employee exposure" means that exposure to airborne asbestos that would occur if the employee were not using respiratory protective equipment.

"Equipment room (change room)" means a contaminated room located within the decontamination area that is supplied with impermeable bags or containers for the disposal of contaminated protective clothing and equipment.

"Fiber" means a particulate form of asbestos, 5 micrometers or longer, with a length-to-diameter ratio of at least 3 to 1.

"Glovebag" means not more than a 60 x 60 inch impervious plastic bag-like enclosure affixed around an asbestos-containing material, with glove-like appendages through which material and tools may be handled.

"High-efficiency particulate air (HEPA) filter" means a filter capable of trapping and retaining at least 99.97 percent of all mono-dispersed particles of 0.3 micrometers in diameter.

"Homogeneous area" means an area of surfacing material or thermal system insulation that is uniform in color and texture.

"Industrial hygienist" means a professional qualified by education, training, and experience to anticipate, recognize, evaluate and develop controls for occupational health hazards.

"Intact" means that the ACM has not crumbled, been pulverized, or otherwise deteriorated so that the asbestos is no longer likely to be bound with its matrix.

"Modification for purposes of paragraph (g)(6)(ii)," means a changed or altered procedure, material or component of a control system, which replaces a procedure, material or component of a required system. Omitting a procedure or component, or reducing or diminishing the stringency or strength of a material or component of the control system is not a "modification" for purposes of paragraph (g)(6) of this section.

"Negative Initial Exposure Assessment" means a demonstration by the employer, which complies with the criteria in paragraph (f)(2)(iii) of this section, that employee exposure during an operation is expected to be consistently below the PELs.

"PACM" means "presumed asbestos containing material".

"Presumed Asbestos Containing Material" means thermal system insulation and surfacing material found in buildings constructed no later than 1980. The designation of a material as "PACM" may be rebutted pursuant to paragraph (k)(5) of this section.

"Project Designer" means a person who has successfully completed the training requirements for an abatement project designer established by 40 U.S.C. Sec. 763.90(g).

"Regulated area" means: an area established by the employer to demarcate areas where Class I, II, and III asbestos work is conducted, and any adjoining area where debris and waste from such asbestos work accumulate; and a work area within which airborne concentrations of asbestos, exceed or there is a reasonable possibility they may exceed the permissible exposure limit. Requirements for regulated areas are set out in paragraph (e) of this section.

"Removal" means all operations where ACM and/or PACM is taken out or stripped from structures or substrates, and includes demolition operations.

"Renovation" means the modifying of any existing structure, or portion thereof.

"Repair" means overhauling, rebuilding, reconstructing, or reconditioning of structures or substrates, including encapsulation or other repair of ACM or PACM attached to structures or substrates.

"Surfacing material" means material that is sprayed, troweled-on or otherwise applied to surfaces (such as acoustical plaster on ceilings and fireproofing materials on structural members, or other materials on surfaces for acoustical, fireproofing, and other purposes).

"Surfacing ACM" means surfacing material which contains more than 1% asbestos.

"Thermal system insulation (TSI)" means ACM applied to pipes, fittings, boilers, breeching, tanks, ducts or other structural components to prevent heat loss or gain.

"Thermal system insulation ACM" is thermal system insulation which contains more than 1% asbestos.

(c) Permissible exposure limits (PELs)

(1) Time-weighted average limit (TWA)

The employer shall ensure that no employee is exposed to an airborne concentration of asbestos in excess of 0.1 fiber per cubic centimeter of air as an eight (8) hour time-weighted average (TWA), as determined by the method prescribed in Appendix A to this section, or by an equivalent method.

(2)Excursion limit

The employer shall ensure that no employee is exposed to an airborne concentration of asbestos in excess of 1.0 fiber per cubic centimeter of air (1 f/cc) as averaged over a sampling period of thirty (30) minutes, as determined by the method prescribed in Appendix A to this section, or by an equivalent method.

(d) Multi-employer worksites.

(1) On multi-employer worksites, an employer performing work requiring the establishment of a regulated area shall inform other employers on the site of the nature of the employer's work with asbestos and/or PACM, of the existence of and requirements pertaining to regulated areas, and the measures taken to ensure that employees of such other employers are not exposed to asbestos.

(2) Asbestos hazards at a multi-employer work site shall be abated by the contractor who created or controls the source of asbestos contamination. For example, if there is a significant breach of an enclosure containing Class I work, the employer responsible for erecting the enclosure shall repair the breach immediately.

(3) In addition, all employers of employees exposed to asbestos hazards shall comply with applicable protective provisions to protect their employees. For example, if employees working immediately adjacent to a Class I asbestos job are exposed to asbestos due to the inadequate containment of such job, their employer shall either remove the employees from the area until the enclosure breach is repaired; or perform an initial exposure assessment pursuant to (f) of this section.

(4) All employers of employees working adjacent to regulated areas established by another employer on a multi-employer work-site, shall take steps on a daily basis to ascertain the integrity of the enclosure and/or the effectiveness of the control method relied on by the primary asbestos contractor to assure that asbestos fibers do not migrate to such adjacent areas.

(5) All general contractors on a construction project which includes work covered by this standard shall be deemed to exercise general supervisory authority over the work covered by this standard, even though the general contractor is not qualified to serve as the asbestos "competent person" as defined by paragraph (b) of this section. As supervisor of the entire project, the general contractor shall ascertain whether the asbestos contractor is in compliance with this standard, and shall require such contractor to come into compliance with this standard when necessary.

(e) Regulated areas

All Class I, II and III asbestos work shall be conducted within regulated areas. All other operations covered by this standard shall be conducted within a regulated area where airborne concentrations of asbestos exceed, or there is a reasonable possibility they may exceed a PEL. Regulated areas shall comply with the requirements of paragraphs (2), (3),(4) and (5) of this section.

(2) Demarcation

The regulated area shall be demarcated in any manner that minimizes the number of persons within the area and protects persons outside the area from exposure to airborne asbestos. Where critical barriers or negative pressure enclosures are used, they may demarcate the regulated area. Signs shall be provided and displayed pursuant to the requirements of paragraph (k)(7) of this section.

(3) Access

Access to regulated areas shall be limited to authorized persons and to persons authorized by the Act or regulations issued pursuant thereto.

(4) Respirators

All persons entering a regulated area where employees are required pursuant to paragraph (h)(1) of this section to wear respirators shall be supplied with a respirator selected in accordance with paragraph (h)(2) of this section.

(5) Prohibited activities

The employer shall ensure that employees do not eat, drink, smoke, chew tobacco or gum, or apply cosmetics in the regulated area.

(6) Competent Persons.

The employer shall ensure that all asbestos work performed within regulated areas is supervised by a competent person, as defined in paragraph (b) of this section. The duties of the competent person are set out in paragraph (o) of this section.

(f) Exposure assessments and monitoring

(1) General monitoring criteria

(i) Each employer who has a workplace or work operation where exposure monitoring is required under this section shall perform monitoring to determine accurately the airborne concentrations of asbestos to which employees may be exposed.

(ii) Determinations of employee exposure shall be made from breathing zone air samples that are representative of the 8-hour TWA and 30-minute short-term exposures of each employee.

(iii) Representative 8-hour TWA employee exposure shall be determined on the basis of one or more samples representing full-shift exposure for employees in each work area. Representative 30-minute short-term employee exposures shall be determined on the basis of one or more samples representing 30 minute exposures associated with operations that are most likely to produce exposures above the excursion limit for employees in each work area.

(2) Initial Exposure Assessment

(i) Each employer who has a workplace or work operation covered by this standard shall ensure that a "competent person" conducts an exposure assessment immediately before or at the initiation of the operation to ascertain expected exposures during that operation or workplace. The assessment must be completed in time to comply with requirements which are triggered by exposure data or the lack of a "negative exposure assessment," and to provide information necessary to assure that all control systems planned are appropriate for that operation and will work properly.

(ii) Basis of Initial Exposure Assessment: Unless a negative exposure assessment has been made pursuant to paragraph (f)(2)(iii) of this section, the initial exposure assessment shall, if feasible, be based on monitoring conducted pursuant to paragraph (f)(1)(iii) of this section. The assessment shall take into consideration both the monitoring results and all observations, information or calculations which indicate employee exposure to asbestos, including any previous monitoring conducted in the workplace, or of the operations of the employer which indicate the levels of airborne asbestos likely to be encountered on the job. For Class I asbestos work, until the employer conducts exposure monitoring and documents that employees on that job will not be exposed in excess of the PELs, or otherwise makes a negative exposure assessment pursuant to paragraph (f)(2)(iii) of this section, the employer shall presume that employees are exposed in excess of the TWA and excursion limit.

REGULATIONS

(iii) Negative Exposure Assessment: For any one specific asbestos job which will be performed by employees who have been trained in compliance with the standard, the employer may demonstrate that employee exposures will be below the PELs by data which conform to the following criteria;

(A) Objective data demonstrating that the product or material containing asbestos minerals or the activity involving such product or material cannot release airborne fibers in concentrations exceeding the TWA and excursion limit under those work conditions having the greatest potential for releasing asbestos; or

(B) Where the employer has monitored prior asbestos jobs for the PEL and the excursion limit within 12 months of the current or projected job, the monitoring and analysis were performed in compliance with the asbestos standard in effect; and the data were obtained during work operations conducted under workplace conditions "closely resembling" the processes, type of material, control methods, work practices, and environmental conditions used and prevailing in the employer's current operations, the operations were conducted by employees whose training and experience are no more extensive than that of employees performing the current job, and these data show that under the conditions prevailing and which will prevail in the current workplace there is a high degree of certainty that employee exposures will not exceed the TWA and excursion limit; or

(C) The results of initial exposure monitoring of the current job made from breathing zone air samples that are representative of the 8-hour TWA and 30-minute short-term exposures of each employee covering operations which are most likely during the performance of the entire asbestos job to result in exposures over the PELs.

(3) Periodic monitoring

(i) Class I and II operations. The employer shall conduct daily monitoring that is representative of the exposure of each employee who is assigned to work within a regulated area who is performing Class I or II work, unless the employer pursuant to (f)(2)(iii) of this section, has made a negative exposure assessment for the entire operation.

(ii) All operations under the standard other than Class I and II operations. The employer shall conduct periodic monitoring of all work where exposures are expected to exceed a PEL, at intervals sufficient to document the validity of the exposure prediction.

(iii) Exception: When all employees required to be monitored daily are equipped with supplied-air respirators operated in the pressure demand mode, or other positive pressure mode respirator, the employer may dispense with the daily monitoring required by this paragraph. However, employees performing Class I work using a control method which is not listed in paragraph (g)(4)(i), (ii), or (iii) of this section or using a modification of a listed control method, shall continue to be monitored daily even if they are equipped with supplied-air respirators.

(4) Termination of monitoring

(i) If the periodic monitoring required by paragraph (f)(3) of this section reveals that employee exposures, as indicated by statistically reliable measurements, are below the permissible exposure limit and excursion limit the employer may discontinue monitoring for those employees whose exposures are represented by such monitoring.

(ii) Additional monitoring. Notwithstanding the provisions of paragraph (f)(2) and (3), and (f)(4) of this section, the employer shall institute the exposure monitoring required under paragraph (f)(3) of this section whenever there has been a change in process, control equipment, personnel or work practices that may result in new or additional exposures above the permissible exposure limit and/or excursion limit or when the employer has any reason to suspect that a change may result in new or additional exposures above the permissible exposure limit and/or excursion limit. Such additional monitoring is required regardless of whether a "negative exposure assessment" was previously produced for a specific job.

(5) Employee notification of monitoring results

(i) The employer shall notify affected employees of the monitoring results that represent that employee's exposure as soon as possible following receipt of monitoring results.

(ii) The employer shall notify affected employees of the results of monitoring representing the employee's exposure in writing either individually or by posting at a centrally located place that is accessible to affected employees.

(6) Observation of monitoring

(i) The employer shall provide affected employees and their designated representatives an opportunity to observe any monitoring of employee exposure to asbestos conducted in accordance with this section.

(ii) When observation of the monitoring of employee exposure to asbestos requires entry into an area where the use of protective clothing or equipment is required, the observer shall be provided with and be required to use such clothing and equipment and shall comply with all other applicable safety and health procedures.

(g) Methods of compliance

(1) Engineering controls and work practices for all operations covered by this section. The employer shall use the following engineering controls and work practices in all operations covered by this section, regardless of the levels of exposure:

(i) Vacuum cleaners equipped with HEPA filters to collect all debris and dust containing ACM and PACM, except as provided in paragraph (g)(8)(ii) of this section in the case of roofing material.

(ii) Wet methods, or wetting agents, to control employee exposures during asbestos handling, mixing, removal, cutting, application, and cleanup, except where employers demonstrate that the use of wet methods is infeasible due to for example, the creation of electrical hazards, equipment malfunction, and, in roofing, except as provide in paragraph (g)(8)(ii) of this section; and

(iii) Prompt clean-up and disposal of wastes and debris contaminated with asbestos in leak-tight containers except in roofing operations, where the procedures specified in paragraph (g)(8)(ii) of this section apply.

(2) In addition to the requirements of paragraph (g)(1) of this section, the employer shall use the following control methods to achieve compliance with the TWA permissible exposure limit and excursion limit prescribed by paragraph (c) of this section;

(i) Local exhaust ventilation equipped with HEPA filter dust collection systems;

(ii) Enclosure or isolation of processes producing asbestos dust;

(iii) Ventilation of the regulated area to move contaminated air away from the breathing zone of employees and toward a filtration or collection device equipped with a HEPA filter;

(iv) Use of other work practices and engineering controls that the Assistant Secretary can show to be feasible.

(v) Wherever the feasible engineering and work practice controls described above are not sufficient to reduce employee exposure to or below the permissible exposure limit and/or excursion limit prescribed in paragraph (c) of this section, the employer shall use them to reduce employee exposure to the lowest levels attainable by these controls and shall supplement them by the use of respiratory protection that complies with the requirements of paragraph (h) of this section.

(3) Prohibitions.

The following work practices and engineering controls shall not be used for work related to asbestos or for work which disturbs ACM or PACM, regardless of measured levels of asbestos exposure or the results of initial exposure assessments:

(i) High-speed abrasive disc saws that are not equipped with point of cut ventilator or enclosures with HEPA filtered exhaust air.

(ii) Compressed air used to remove asbestos, or materials containing asbestos, unless the compressed air is used in conjunction with an enclosed ventilation system designed to capture the dust cloud created by the compressed air.

(iii) Dry sweeping, shoveling or other dry clean-up of dust and debris containing ACM and PACM.

(iv) Employee rotation as a means of reducing employee exposure to asbestos.

(4) Class I Requirements.

In addition to the provisions of paragraphs (g)(1) and (2) of this section, the following engineering controls and work practices and procedures shall be used.

(i) All Class I work, including the installation and operation of the control system shall be supervised by a competent person as defined in paragraph (b) of this section;

(ii) For all Class I jobs involving the removal of more than 25 linear or 10 square feet of thermal system insulation or surfacing material; for all other Class I jobs, where the employer cannot produce a negative exposure assessment pursuant to paragraph (f)(2)(iii) of this section, or where employees are working in areas adjacent to the regulated area, while the Class I work is

REGULATIONS

being performed, the employer shall use one of the following methods to ensure that airborne asbestos does not migrate from the regulated area:

(A) Critical barriers shall be placed over all the openings to the regulated area, except where activities are performed outdoors; or

(B) The employer shall use another barrier or isolation method which prevents the migration of airborne asbestos from the regulated area, as verified by perimeter area surveillance during each work shift at each boundary of the regulated area, showing no visible asbestos dust; and perimeter area monitoring showing that clearance levels contained in 40 CFR Part 763, Subpt. E, of the EPA Asbestos in Schools Rule are met, or that perimeter area levels, measured by Phase Contrast Microscopy (PCM) are no more than background levels representing the same area before the asbestos work began. The results of such monitoring shall be made known to the employer no later than 24 hours from the end of the work shift represented by such monitoring. Exception: For work completed outdoors where employees are not working in areas adjacent to the regulated areas, this paragraph (g)(4)(ii) is satisfied when the specific control methods in paragraph (g)(5) of this section are used.

(iii) For all Class I jobs, HVAC systems shall be isolated in the regulated area by sealing with a double layer of 6 mil plastic or the equivalent;

(iv) For all Class I jobs, impermeable dropcloths shall be placed on surfaces beneath all removal activity;

(v) For all Class I jobs, all objects within the regulated area shall be covered with impermeable dropcloths or plastic sheeting which is secured by duct tape or an equivalent.

(vi) For all Class I jobs where the employer cannot produce a negative exposure assessment, or where exposure monitoring shows that a PEL is exceeded, the employer shall ventilate the regulated area to move contaminated air away from the breathing zone of employees toward a HEPA filtration or collection device.

(5) Specific control methods for Class I work.

In addition, Class I asbestos work shall be performed using one or more of the following control methods pursuant to the limitations stated below:

(i) Negative Pressure Enclosure (NPE) systems: NPE systems may be used where the configuration of the work area does not make the erection of the enclosure infeasible, with the following specifications and work practices.

(A) Specifications:

(1) The negative pressure enclosure (NPE) may be of any configuration,

(2) At least 4 air changes per hour shall be maintained in the NPE,

(3) A minimum of -0.02 column inches of water pressure differential, relative to outside pressure, shall be maintained within the NPE as evidenced by manometric measurements,

(4) The NPE shall be kept under negative pressure throughout the period of its use, and

(5) Air movement shall be directed away from employees performing asbestos work within the enclosure, and toward a HEPA filtration or a collection device.

(B) Work Practices:

(1) Before beginning work within the enclosure and at the beginning of each shift, the NPE shall be inspected for breaches and smoke-tested for leaks, and any leaks sealed.

(2) Electrical circuits in the enclosure shall be deactivated, unless equipped with ground-fault circuit interrupters.

(ii) Glove bag systems may be used to remove PACM and/or ACM from straight runs of piping and elbows and other connections with the following specifications and work practices:

(A) Specifications:

(1) Glovebags shall be made of 6 mil thick plastic and shall be seamless at the bottom.

(2) Glovebags used on elbows and other connections must be designed for that purpose and used without modifications.

(B) Work Practices:

(1) Each glovebag shall be installed so that it completely covers the circumference of pipe or other structure where the work is to be done.

(2) Glovebags shall be smoke-tested for leaks and any leaks sealed prior to use.

(3) Glovebags may be used only once and may not be moved.

(4) Glovebags shall not be used on surfaces whose temperature exceeds 150 deg. F.

(5) Prior to disposal, glovebags shall be collapsed by removing air within them using a HEPA vacuum.

(6) Before beginning the operation, loose and friable material adjacent to the glovebag/box operation shall be wrapped and sealed in two layers of six mil plastic or otherwise rendered intact,

(7) Where system uses attached waste bag, such bag shall be connected to collection bag using hose or other material which shall withstand pressure of ACM waste and water without losing its integrity:

(8) Sliding valve or other device shall separate waste bag from hose to ensure no exposure when waste bag is disconnected:

(9) At least two persons shall perform Class I glovebag removal operations.

(iii) Negative Pressure Glove Bag Systems. Negative pressure glove bag systems may be used to remove ACM or PACM from piping.

(A) Specifications: In addition to specifications for glove bag systems above, negative pressure glove bag systems shall attach HEPA vacuum systems or other devices to bag to prevent collapse during removal.

(B) Work Practices:

(1) The employer shall comply with the work practices for glove bag systems in paragraph (g)(5)(ii)(B)(4) of this section.

(2) The HEPA vacuum cleaner or other device used to prevent collapse of bag during removal shall run continually during the operation until it is completed at which time the bag shall be collapsed prior to removal of the bag from the pipe.

(3) Where a separate waste bag is used along with a collection bag and discarded after one use, the collection bag may be reused if rinsed clean with amended water before reuse.

(iv) Negative Pressure Glove Box Systems: Negative pressure glove boxes may be used to remove ACM or PACM from pipe runs with the following specifications and work practices.

(A) Specifications:

(1) Glove boxes shall be constructed with rigid sides and made from metal or other material which can withstand the weight of the ACM and PACM and water used during removal:

(2) A negative pressure generator shall be used to create negative pressure in the system:

(3) An air filtration unit shall be attached to the box:

(4) The box shall be fitted with gloved apertures:

(5) An aperture at the base of the box shall serve as a bagging outlet for waste ACM and water:

(6) A back-up generator shall be present on site:

(7) Waste bags shall consist of 6 mil thick plastic double-bagged before they are filled or plastic thicker than 6 mil.

(B) Work practices:

(1) At least two persons shall perform the removal:

(2) The box shall be smoke-tested for leaks and any leaks sealed prior to each use:

(3) Loose or damaged ACM adjacent to the box shall be wrapped and sealed in two layers of 6 mil plastic prior to the job, or otherwise made intact prior to the job.

(4) A HEPA filtration system shall be used to maintain pressure barrier in box.

(v) Water Spray Process System. A water spray process system may be used for removal of ACM and PACM from cold line piping if, employees carrying out such process have completed a 40-hour separate training course in its use, in addition to training required for employees performing Class I work. The system shall meet the following specifications and shall be performed by employees using the following work practices.

(A) Specifications:

(1) Piping shall be surrounded on 3 sides by rigid framing,

(2) A 360 degree water spray, delivered through nozzles supplied by a high pressure separate water line, shall be formed around the piping.

(3) The spray shall collide to form a fine aerosol which provides a liquid barrier between workers and the ACM and PACM.

(B) Work Practices:

(1) The system shall be run for at least 10 minutes before removal begins.

(2) All removal shall take place within the water barrier.

(3) The system shall be operated by at least three persons, one of whom shall not perform removal, but shall check equipment, and ensure proper operation of the system.

(4) After removal, the ACM and PACM shall be bagged while still inside the water barrier.

(vi) A small walk-in enclosure which accommodates no more than two persons (mini-enclosure) may be used if the disturbance or removal can be completely contained by the enclosure with the following specifications and work practices.

(A) Specifications:

(1) The fabricated or job-made enclosure shall be constructed of 6 mil plastic or equivalent:

(2) The enclosure shall be placed under negative pressure by means of a HEPA filtered vacuum or similar ventilation unit:

(B) Work practices:

(1) Before use, the mini-enclosure shall be inspected for leaks and smoke-tested to detect breaches, and breaches sealed.

(2) Before reuse, the interior shall be completely washed with amended water and HEPA-vacuumed.

(3) During use, air movement shall be directed away from the employee's breathing zone within the mini-enclosure.

(6) Alternative control methods for Class I work.

Class I work may be performed using a control method which is not referenced in paragraph (g)(5) of this section, or which modifies a control method referenced in paragraph (g)(5)of this section, if the following provisions are complied with:

(i) The control method shall enclose, contain or isolate the processes or source of airborne asbestos dust, or otherwise capture or redirect such dust before it enters the breathing zone of employees.

(ii) A certified industrial hygienist or licensed professional engineer who is also qualified as a project designer as defined in paragraph (b) of this section, shall evaluate the work area, the projected work practices and the engineering controls and shall certify in writing that the planned control method is adequate to reduce direct and indirect employee exposure to below the PELs under worst-case conditions of use, and that the planned control method will prevent asbestos contamination outside the regulated area, as measured by clearance sampling which meets the requirements of EPA's Asbestos in Schools rule issued under AHERA, or perimeter monitoring which meets the criteria in paragraph (g)(4)(ii)(B) of this section.

(A) Where the TSI or surfacing material to be removed is 25 linear or 10 square feet or less , the evaluation required in paragraph (g)(6) of this section may be performed by a "competent person", and may omit consideration of perimeter or clearance monitoring otherwise required.

(B) The evaluation of employee exposure required in paragraph (g)(6) of this section, shall include and be based on sampling and analytical data representing employee exposure during the use of such method under worst-case conditions and by employees whose training and experience are equivalent to employees who are to perform the current job.

(iii) Before work which involves the removal of more than 25 linear or 10 square feet of thermal system insulation or surfacing material is begun using an alternative method which has been the subject of a paragraph (g)(6) of this section required evaluation and certification, the employer shall send a copy of such evaluation and certification to the national office of OSHA, Office of Technical Support, Room N3653, 200 Constitution Avenue, NW, Washington, DC 20210. The submission shall not constitute approval by OSHA.

(7) Work Practices and Engineering Controls for Class II work

(i) All Class II work shall be supervised by a competent person as defined in paragraph (b) of this section.

(ii) For all indoor Class II jobs, where the employer has not produced a negative exposure assessment pursuant to paragraph (f)(2)(iii) of this section, or where during the job, changed conditions indicate there may be exposure above the PEL or where the employer does not remove the ACM in a substantially intact state, the employer shall use one of the following methods to ensure that airborne asbestos does not migrate from the regulated area;

(A) Critical barriers shall be placed over all openings to the regulated area; or,

(B) The employer shall use another barrier or isolation method which prevents the migration of airborne asbestos from the regulated area, as verified by perimeter area monitoring or clearance monitoring which meets the criteria set out in paragraph (g)(4)(ii)(B) of this section.

(C) Impermeable dropcloths shall be placed on surfaces beneath all removal activity;

(iii) [Reserved]

(iv) All Class II asbestos work shall be performed using the work practices and requirements set out above in paragraph (g)(1)(i) through (g)(1)(iii) of this section.

(8) Additional Controls for Class II work.

Class II asbestos work shall also be performed by complying with the work practices and controls designated for each type of asbestos work to be performed, set out in this paragraph. Where more than one control method may be used for a type of asbestos work, the employer may choose one or a combination of designated control methods. Class II work also may be performed using a method allowed for Class I work, except that glove bags and glove boxes are allowed if they fully enclose the Class II material to be removed.

(i) For removing vinyl and asphalt flooring materials which contain ACM or for which in buildings constructed no later than 1980, the employer has not verified the absence of ACM pursuant to paragraph (g)(8)(i)(I) of this section. The employer shall ensure that employees comply with the following work practices and that employees are trained in these practices pursuant to paragraph (k)(9) of this section:

(A) Flooring or its backing shall not be sanded.

(B) Vacuums equipped with HEPA filter, disposable dust bag, and metal floor tool (no brush) shall be used to clean floors.

(C) Resilient sheeting shall be removed by cutting with wetting of the snip point and wetting during delamination. Rip-up of resilient sheet floor material is prohibited.

(D) All scraping of residual adhesive and/or backing shall be performed using wet methods.

(E) Dry sweeping is prohibited.

(F) Mechanical chipping is prohibited unless performed in a negative pressure enclosure which meets the requirements of paragraph (g)(5)(i) of this section.

(G) Tiles shall be removed intact, unless the employer demonstrates that intact removal is not possible.

(H) When tiles are heated and can be removed intact, wetting may be omitted.

(I) Resilient flooring material including associated mastic and backing shall be assumed to be asbestos-containing unless an industrial hygienist determines that it is asbestos-free using recognized analytical techniques.

(ii) For removing roofing material which contains ACM the employer shall ensure that the following work practices are followed:

(A) Roofing material shall be removed in an intact state to the extent feasible.

(B) Wet methods shall be used to remove roofing materials that are not intact, or that will be rendered not intact during removal, unless such wet methods are not feasible or will create safety hazards.

(C) Cutting machines shall be continuously misted during use, unless a competent person determines that misting substantially decreases worker safety.

(D) When removing built-up roofs with asbestos-containing roofing felts and an aggregate surface using a power roof cutter, all dust resulting from the cutting operation shall be collected by a HEPA dust collector, or shall be HEPA vacuumed by vacuuming along the cut line. When removing built-up roofs with asbestos-containing roofing felts and a smooth surface using a power roof cutter, the dust resulting from the cutting operation shall be collected either by a HEPA dust collector or HEPA vacuuming along the cut line, or by gently sweeping and then carefully and completely wiping up the still-wet dust and debris left along the cut line.

(E) Asbestos-containing material that has been removed from a roof shall not be dropped or thrown to the ground. Unless the material is carried or passed to the ground by hand, it shall be lowered to the ground via covered, dust-tight chute, crane or hoist:

(1) Any ACM that is not intact shall be lowered to the ground as soon as is practicable, but in any event no later than the end of the work shift. While the material remains on the roof it shall either be kept wet, placed in an impermeable waste bag, or wrapped in plastic sheeting.

(2) Intact ACM shall be lowered to the ground as soon as is practicable, but in any event no later than the end of the work shift.

(F) Upon being lowered, unwrapped material shall be transferred to a closed receptacle in such manner so as to preclude the dispersion of dust.

(G) Roof level heating and ventilation air intake sources shall be isolated or the ventilation system shall be shut down.

(H) Notwithstanding any other provision of this section, removal or repair of sections of intact roofing less than 25 square feet in area does not require use of wet methods or

HEPA vacuuming as long as manual methods which do not render the material non-intact are used to remove the material and no visible dust is created by the removal method used. In determining whether a job involves less than 25 square feet, the employer shall include all removal and repair work performed on the same roof on the same day.

(iii) When removing cementitious asbestos-containing siding and shingles or transite panels containing ACM on building exteriors (other than roofs, where paragraph (g)(8)(ii) of this section applies) the employer shall ensure that the following work practices are followed:

(A) Cutting, abrading or breaking siding, shingles, or transite panels, shall be prohibited unless the employer can demonstrate that methods less likely to result in asbestos fiber release cannot be used.

(B) Each panel or shingle shall be sprayed with amended water prior to removal.

(C) Unwrapped or unbagged panels or shingles shall be immediately lowered to the ground via covered dust-tight chute, crane or hoist, or placed in an impervious waste bag or wrapped in plastic sheeting and lowered to the ground no later than the end of the work shift.

(D) Nails shall be cut with flat, sharp instruments.

(iv) When removing gaskets containing ACM, the employer shall ensure that the following work practices are followed:

(A) If a gasket is visibly deteriorated and unlikely to be removed intact, removal shall be undertaken within a glovebag as described in paragraph (g)(5)(ii) of this section.

(B) [Reserved]

(C) The gasket shall be immediately placed in a disposal container.

(D) Any scraping to remove residue must be performed wet.

(v) When performing any other Class II removal of asbestos containing material for which specific controls have not been listed in paragraph (g)(8)(iv)(A) through (D) of this section, the employer shall ensure that the following work practices are complied with.

(A) The material shall be thoroughly wetted with amended water prior to and during its removal.

(B) The material shall be removed in an intact state unless the employer demonstrates that intact removal is not possible.

(C) Cutting, abrading or breaking the material shall be prohibited unless the employer can demonstrate that methods less likely to result in asbestos fiber release are not feasible.

(D) Asbestos-containing material removed, shall be immediately bagged or wrapped, or kept wetted until transferred to a closed receptacle, no later than the end of the work shift.

(vi) Alternative Work Practices and Controls. Instead of the work practices and controls listed in paragraph (g)(8)(i) through (v) of this section, the employer may use different or modified engineering and work practice controls if the following provisions are complied with.

(A) The employer shall demonstrate by data representing employee exposure during the use of such method under conditions which closely resemble the conditions under which the method is to be used, that employee exposure will not exceed the PELs under any anticipated circumstances.

(B) A competent person shall evaluate the work area, the projected work practices and the engineering controls, and shall certify in writing, that the different or modified controls are adequate to reduce direct and indirect employee exposure to below the PELs under all expected conditions of use and that the method meets the requirements of this standard. The evaluation shall include and be based on data representing employee exposure during the use of such method under conditions which closely resemble the conditions under which the method is to be used for the current job, and by employees whose training and experience are equivalent to employees who are to perform the current job.

(9) Work Practices and Engineering Controls for Class III asbestos work.

Class III asbestos work shall be conducted using engineering and work practice controls which minimize the exposure to employees performing the asbestos work and to bystander employees.

(i) The work shall be performed using wet methods.

(ii) To the extent feasible, the work shall be performed using local exhaust ventilation.

(iii) Where the disturbance involves drilling, cutting, abrading, sanding, chipping, breaking, or sawing of thermal system insulation or surfacing material, the employer shall use impermeable dropcloths, and shall isolate the operation using mini-enclosures or glove bag systems pursuant to paragraph (g)(5) of this section or another isolation method.

(iv) Where the employer does not produce a "negative exposure assessment" for a job, or where monitoring results show the PEL has been exceeded, the employer shall contain the area using impermeable dropcloths and plastic barriers or their equivalent, or shall isolate the operation using a control system listed in and in compliance with paragraph (g)(5) of this section.

(v) Employees performing Class III jobs, which involve the disturbance of thermal system insulation or surfacing material, or where the employer does not produce a "negative exposure assessment" or where monitoring results show a PEL has been exceeded, shall wear respirators which are selected, used and fitted pursuant to provisions of paragraph (h) of this section.

(10) Class IV asbestos work.

Class IV asbestos jobs shall be conducted by employees trained pursuant to the asbestos awareness training program set out in paragraph (k)(9) of this section. In addition, all Class IV jobs shall be conducted in conformity with the requirements set out in paragraph (g)(1) of this section, mandating wet methods, HEPA vacuums, and prompt clean up of debris containing ACM or PACM.

(i) Employees cleaning up debris and waste in a regulated area where respirators are required shall wear respirators which are selected, used and fitted pursuant to provisions of paragraph (h) of this section.

(ii) Employers of employees who clean up waste and debris in, and employers in control of, areas where friable thermal system insulation or surfacing material is accessible, shall assume that such waste and debris contain asbestos.

(11) Alternative methods of compliance for installation, removal, repair, and maintenance of certain roofing and pipeline coating materials.

Notwithstanding any other provision of this section, an employer who complies with all provisions of this paragraph (g)(11) when installing, removing, repairing, or maintaining intact pipeline asphaltic wrap, or roof flashings which contain asbestos fibers encapsulated or coated by bituminous or resinous compounds shall be deemed to be in compliance with this section. If an employer does not comply with all provisions of this paragraph (g)(11) or if during the course of the job the material does not remain intact, the provisions of paragraph (g)(8) of this section apply instead of this paragraph (g)(11).

(i) Before work begins and as needed during the job, a competent person who is capable of identifying asbestos hazards in the workplace and selecting the appropriate control strategy for asbestos exposure, and who has the authority to take prompt corrective measures to eliminate such hazards, shall conduct an inspection of the worksite and determine that the roofing material is intact and will likely remain intact.

(ii) All employees performing work covered by this paragraph (g)(11) shall be trained in a training program that meets the requirements of paragraph (k)(9)(viii) of this section.

(iii) The material shall not be sanded, abraded, or ground. Manual methods which do not render the material non-intact shall be used.

(iv) Material that has been removed from a roof shall not be dropped or thrown to the ground. Unless the material is carried or passed to the ground by hand, it shall be lowered to the ground via covered, dust-tight chute, crane or hoist. All such material shall be removed from the roof as soon as is practicable, but in any event no later than the end of the work shift.

(v) Where roofing products which have been labeled as containing asbestos pursuant to paragraph (k)(8) of this section are installed on non-residential roofs during operations covered by this paragraph (g)(11), the employer shall notify the building owner of the presence and location of such materials no later than the end of the job.

(vi) All removal or disturbance of pipeline asphaltic wrap shall be performed using wet methods.

(h) Respiratory protection.

(1) General

For employees who use respirators required by this section, the employer must provide respirators that comply with the requirements of this paragraph. Respirators must be used during:

(i) Class I asbestos work.

(ii) Class II asbestos work when ACM is not removed in a substantially intact state.

(iii) Class II and III asbestos work that is not performed using wet methods, except for removal of ACM from sloped roofs when a negative-exposure assessment has been conducted and ACM is removed in an intact state.

(iv) Class II and III asbestos work for which a negative-exposure assessment has not been conducted.

(v) Class III asbestos work when TSI or surfacing ACM or PACM is being disturbed.

(vi) Class IV asbestos work performed within regulated areas where employees who are performing other work are required to use respirators.

(vii) Work operations covered by this section for which employees are exposed above the TWA or excursion limit.

(viii) Emergencies.

(2) Respirator program

(i) The employer must implement a respiratory protection program in accordance with 29 CFR 1910.134 (b) through (d) (except (d)(1)(iii)), and (f) through (m).

(ii) No employee shall be assigned to asbestos work that requires respirator use if, based on their most recent medical examination, the examining physician determines that the employee will be unable to function normally while using a respirator, or that the safety or health of the employee or other employees will be impaired by the employee's respirator use. Such employees must be assigned to another job or given the opportunity to transfer to a different position that they can perform. If such a transfer position is available, it must be with the same employer, in the same geographical area, and with the same seniority, status, rate of pay, and other job benefits the employee had just prior to such transfer.

(3) Respirator selection

(i) The employer must select the appropriate respirator from Table 1 of this section.

(ii) The employer must provide an employee with a tight-fitting, powered air-purifying respirator instead of a negative-pressure

TABLE 1. – RESPIRATORY PROTECTION FOR ASBESTOS FIBERS

Airborne concentration of asbestos or conditions of use	Required Respirator
Not in excess of 1 f/cc (10 x PEL), or otherwise as required independent of exposure pursuant to paragraph (h)(2)(iv) of this section.	Half-mask air purifying respirator other than a disposable respirator, equipped with high efficiency filters.
Not in excess of 5 f/cc (50 x PEL)	Full facepiece air purifying respirator equipped with high efficiency filters.
Not in excess of 10 f/cc (100 x PEL)	Any powered air purifying respirator equipped with high efficiency filters or any supplied air respirator operated in continuous flow mode.
Not in excess of 100 f/cc (1,000 x PEL) or unknown concentration	Full facepiece supplied air respirator operated in pressure demand mode.
Greather than 100 f/cc (1,000 x PEL), or unknown concentration	Full facepiece supplied air respirator operated in pressure demand mode, equipped with an auxiliary positive pressure self-contained breathing apparatus.

respirator from Table 1 when the employee chooses to use this type of respirator and such a respirator will provide adequate protection to the employee.

(iii) The employer must provide a half-mask air-purifying respirator, other than a disposable respirator, that is equipped with high-efficiency filters when the employee performs:

(A) Class II and III asbestos work and a negative-exposure assessment has not been conducted by the employer.

(B) Class III asbestos work when TSI or surfacing ACM or PACM is being disturbed.

(iv) In addition to the above selection criteria, when employees are in a regulated area where Class I work is being performed, a negative exposure assessment of the area has not been produced, and the exposure assessment of the area indicates the exposure level will not exceed 1 f/cc as an 8-hour time weighted average, employers must provide the employees with one of the following respirators:

(A) A tight-fitting powered air-purifying respirator equipped with high efficiency filters;

(B) A full facepiece supplied-air respirator operated in the pressure-demand mode equipped with HEPA egress cartridges; or

(C) A full facepiece supplied-air respirator operated in the pressure-demand mode equipped with an auxiliary positive pressure self-contained breathing apparatus. A full facepiece supplied-air respirator operated in the pressure-demand mode equipped with an auxiliary positive pressure self-contained breathing apparatus must be provided under such conditions when the exposure assessment indicates exposure levels above 1 f/cc as an 8-hour time weighted average.

(i) Protective clothing

(1) General

The employer shall provide and require the use of protective clothing, such as coveralls or similar whole-body clothing, head coverings, gloves, and foot coverings for any employee exposed to airborne concentrations of asbestos that exceed the TWA and/or excursion limit prescribed in paragraph (c) of this section, or for which a required negative exposure assessment is not produced, or for any employee performing Class I operations which involve the removal of over 25 linear or 10 square feet of TSI or surfacing ACM and PACM.

(2) Laundering

(i) The employer shall ensure that laundering of contaminated clothing is done so as to prevent the release of airborne asbestos in excess of the TWA or excursion limit prescribed in paragraph (c) of this section.

(ii) Any employer who gives contaminated clothing to another person for laundering shall inform such person of the requirement in paragraph (i)(2)(i) of this section to effectively prevent the release of airborne asbestos in excess of the TWA and excursion limit prescribed in paragraph (c) of this section.

(3) Contaminated clothing

Contaminated clothing shall be transported in sealed impermeable bags, or other closed, impermeable containers, and be labeled in accordance with paragraph (k) of this section.

(4) Inspection of protective clothing

(i) The competent person shall examine worksuits worn by employees at least once per workshift for rips or tears that may occur during performance of work.

(ii) When rips or tears are detected while an employee is working, rips and tears shall be immediately mended, or the worksuit shall be immediately replaced.

(j) Hygiene facilities and practices for employees.

(1) Requirements for employees performing Class I asbestos jobs involving over 25 linear or 10 square feet of TSI or surfacing ACM and PACM.

(i) Decontamination areas: the employer shall establish a decontamination area that is adjacent and connected to the regulated area for the decontamination of such employees. The decontamination area shall consist of an equipment room, shower area, and clean room in series. The employer shall ensure that employees enter and exit the regulated area through the decontamination area.

(A) Equipment room. The equipment room shall be supplied with impermeable, labeled bags and containers for the containment and disposal of contaminated protective equipment.

(B) Shower area. Shower facilities shall be provided which comply with 29 CFR 1910.141(d)(3), unless the employer can demonstrate that they are not feasible. The showers shall be adjacent both to the equipment room and the clean room, unless the employer can demonstrate that this location is not feasible. Where the employer can demonstrate that it is not feasible to locate the shower between the equipment room and the clean room, or where the work is performed outdoors, the employers shall ensure that employees:

(1) Remove asbestos contamination from their worksuits in the equipment room using a HEPA vacuum before proceeding to a shower that is not adjacent to the work area; or

(2) Remove their contaminated worksuits in the equipment room, then don clean worksuits, and proceed to a shower that is not adjacent to the work area.

(C) Clean change room. The clean room shall be equipped with a locker or appropriate storage container for each employee's use. When the employer can demonstrate that it is not feasible to provide a clean change area adjacent to the work area or where the work is performed outdoors, the employer may permit employees engaged in Class I asbestos jobs to clean their protective clothing with a portable HEPA-equipped vacuum before such employees leave the regulated area. Following showering, such employees however must then change into street clothing in clean change areas provided by the employer which otherwise meet the requirements of this section.

(ii) Decontamination area entry procedures. The employer shall ensure that employees:

(A) Enter the decontamination area through the clean room;

(B) Remove and deposit street clothing within a locker provided for their use; and

(C) Put on protective clothing and respiratory protection before leaving the clean room.

(D) Before entering the regulated area, the employer shall ensure that employees pass through the equipment room.

(iii) Decontamination area exit procedures. The employer shall ensure that:

(A) Before leaving the regulated area, employees shall remove all gross contamination and debris from their protective clothing.

(B) Employees shall remove their protective clothing in the equipment room and deposit the clothing in labeled impermeable bags or containers.

(C) Employees shall not remove their respirators in the equipment room.

(D) Employees shall shower prior to entering the clean room.

(E) After showering, employees shall enter the clean room before changing into street clothes.

(iv) Lunch Areas. Whenever food or beverages are consumed at the worksite where employees are performing Class I asbestos work, the employer shall provide lunch areas in which the airborne concentrations of asbestos are below the permissible exposure limit and/or excursion limit.

(2) Requirements for Class I work involving less than 25 linear or 10 square feet of TSI or surfacing ACM and PACM, and for Class II and Class III asbestos work operations where exposures exceed a PEL or where there is no negative exposure assessment produced before the operation.

(i) The employer shall establish an equipment room or area that is adjacent to the regulated area for the decontamination of employees and their equipment which is contaminated with asbestos which shall consist of an area covered by a impermeable drop cloth on the floor or horizontal working surface.

(ii) The area must be of sufficient size as to accommodate cleaning of equipment and removing personal protective equipment without spreading contamination beyond the area (as determined by visible accumulations).

(iii) Work clothing must be cleaned with a HEPA vacuum before it is removed.

(iv) All equipment and surfaces of containers filled with ACM must be cleaned prior to removing them from the equipment room or area.

(v) The employer shall ensure that employees enter and exit the regulated area through the equipment room or area.

(3) Requirements for Class IV work. Employers shall ensure that employees performing Class IV work within a regulated area comply with the hygiene practice required of employees performing work which has a higher classification within that regulated area. Otherwise employers of employees cleaning up debris and material which is TSI or surfacing ACM or identified as PACM shall provide decontamination facilities for such employees which are required by paragraph (j)(2) of this section.

(4) Smoking in work areas.

The employer shall ensure that employees do not smoke in work areas where they are occupationally exposed to asbestos because of activities in that work area.

(k) Communication of hazards

(1) This section applies to the communication of information concerning asbestos hazards in construction activities to facilitate compliance with this standard. Most asbestos-related construction activities involve previously installed building materials. Building owners often are the only and/or best sources of information concerning them. Therefore, they, along with employers of potentially exposed employees, are assigned specific information conveying and retention duties under this section. Installed Asbestos Containing Building Material. Employers and building owners shall identify TSI and sprayed or troweled on surfacing materials in buildings as asbestos-containing, unless they determine in compliance with paragraph (k)(5) of this section that the material is not asbestos-containing. Asphalt and vinyl flooring material installed no later than 1980 must also be considered as asbestos containing unless the employer, pursuant to paragraph (g)(8)(i)(I) of this section determines that it is not asbestos-containing. If the employer/building owner has actual knowledge, or should have known through the exercise of due diligence, that other materials are asbestos-containing, they too must be treated as such. When communicating information to employees pursuant to this standard, owners and employers shall identify "PACM" as ACM. Additional requirements relating to communication of asbestos work on multi-employer worksites are set out in paragraph (d) of this section.

(2) Duties of building and facility owners.

(i) Before work subject to this standard is begun, building and facility owners shall determine the presence, location, and quantity of ACM and/or PACM at the work site pursuant to paragraph (k)(1) of this section.

(ii) Building and/or facility owners shall notify the following persons of the presence, location and quantity of ACM or PACM, at the work sites in their buildings and facilities. Notification either shall be in writing, or shall consist of a personal communication between the owner and the person to whom notification must be given or their authorized representatives:

(A) Prospective employers applying or bidding for work whose employees reasonably can be expected to work in or adjacent to areas containing such material;

(B) Employees of the owner who will work in or adjacent to areas containing such material:

(C) On multi-employer worksites, all employers of employees who will be performing work within or adjacent to areas containing such materials;

(D) Tenants who will occupy areas containing such material.

(3) Duties of employers whose employees perform work subject to this standard in or adjacent to areas containing ACM and PACM. Building/facility owners whose employees perform such work shall comply with these provisions to the extent applicable.

(i) Before work in areas containing ACM and PACM is begun; employers shall identify the presence, location, and quantity of ACM, and/or PACM therein pursuant to paragraph (k)(1) of this section.

(ii) Before work under this standard is performed employers of employees who will perform such work shall inform the following persons of the location and quantity of ACM and/or PACM present in the area and the precautions to be taken to insure that airborne asbestos is confined to the area.

(A) Owners of the building/facility;

(B) Employees who will perform such work and employers of employees who work and/or will be working in adjacent areas.

(iii) Within 10 days of the completion of such work, the employer whose employees have performed work subject to this standard, shall inform the building/facility owner and employers of employees who will be working in the area of the current location and quantity of PACM and/or ACM remaining in the area and final monitoring results, if any.

(4) In addition to the above requirements, all employers who discover ACM and/or PACM on a worksite shall convey information concerning the presence, location and quantity of such newly discovered ACM and/or PACM to the owner and to other employers of employees working at the work site, within 24 hours of the discovery.

(5) Criteria to rebut the designation of installed material as PACM.

(i) At any time, an employer and/or building owner may demonstrate, for purposes of this standard, that PACM does not contain asbestos. Building owners and/or employers are not required to communicate information about the presence of building material for which such a demonstration pursuant to the requirements of paragraph (k)(5)(ii) of this section has been made. However, in all such cases, the information, data and analysis supporting the determination that PACM does not contain asbestos, shall be retained pursuant to paragraph (n) of this section.

(ii) An employer or owner may demonstrate that PACM does not contain more than 1 percent asbestos by the following:

(A) Having a completed inspection conducted pursuant to the requirements of AHERA (40 CFR Part 763, Subpart E) which demonstrates that the material is not ACM; or

(B) Performing tests of the material containing PACM which demonstrate that no ACM is present in the material. Such tests shall include analysis of bulk samples collected in the manner described in 40 CFR 763.86. The tests, evaluation and sample collection shall be conducted by an accredited inspector or by a CIH. Analysis of samples shall be performed by persons or laboratories with proficiency demonstrated by current successful participation in a nationally recognized testing program such as the National Voluntary Laboratory Accreditation Program (NVLAP) or the National Institute for Standards and Technology (NIST) or the Round Robin for bulk samples administered by the American Industrial Hygiene Association (AIHA) or an equivalent nationally-recognized round robin testing program.

(iii) The employer and/or building owner may demonstrate that flooring material including associated mastic and backing does not contain asbestos, by a determination of an industrial hygienist based upon recognized analytical techniques showing that the material is not ACM.

(6) At the entrance to mechanical rooms/areas in which employees reasonably can be expected to enter and which contain ACM and/or PACM, the building owner shall post signs which identify the material which is present, its location, and appropriate work practices which, if followed, will ensure that ACM and/or PACM will not be disturbed. The employer shall ensure, to the extent feasible, that employees who come in contact with these signs can comprehend them. Means to ensure employee comprehension may include the use of foreign languages, pictographs, graphics, and awareness training.

(7) Signs.

(i) Warning signs that demarcate the regulated area shall be provided and displayed at each location where a regulated area is required to be established by paragraph (e) of this section. Signs shall be posted at such a distance from such a location that an employee may read the signs and take necessary protective steps before entering the area marked by the signs.

(ii)(A) The warning signs required by paragraph (k)(7) of this section shall bear the following information.

DANGER
ASBESTOS
CANCER AND LUNG DISEASE HAZARD
AUTHORIZED PERSONNEL ONLY

(B) In addition, where the use of respirators and protective clothing is required in the regulated area under this section, the warning signs shall include the following:

RESPIRATORS AND PROTECTION
CLOTHING ARE REQUIRED IN THIS AREA

(iii) The employer shall ensure that employees working in and contiguous to regulated areas comprehend the warning signs required to be posted by paragraph (k)(7)(i) of this section. Means to ensure employee comprehension may include the use of foreign languages, pictographs and graphics.

(8) Labels.

(i) Labels shall be affixed to all products containing asbestos and to all containers containing such products, including waste containers. Where feasible, installed asbestos products shall contain a visible label.

(ii) Labels shall be printed in large, bold letters on a contrasting background.

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(iii) Labels shall be used in accordance with the requirements of 29 CFR 1910.1200(f) of OSHA's Hazard Communication standard, and shall contain the following information:

DANGER
CONTAINS ASBESTOS FIBERS
AVOID CREATING DUST
CANCER AND LUNG DISEASE HAZARD

(iv) [Reserved]

(v) Labels shall contain a warning statement against breathing asbestos fibers.

(vi) The provisions for labels required by paragraphs (k)(8)(i) through (k)(8)(iii) of this section do not apply where:

(A) Asbestos fibers have been modified by a bonding agent, coating, binder, or other material, provided that the manufacturer can demonstrate that, during any reasonably foreseeable use, handling, storage, disposal, processing, or transportation, no airborne concentrations of asbestos fibers in excess of the permissible exposure limit and/or excursion limit will be released, or

(B) Asbestos is present in a product in concentrations less than 1.0 percent.

(vii) When a building owner or employer identifies previously installed PACM and/or ACM, labels or signs shall be affixed or posted so that employees will be notified of what materials contain PACM and/or ACM. The employer shall attach such labels in areas where they will clearly be noticed by employees who are likely to be exposed, such as at the entrance to mechanical room/areas. Signs required by paragraph (k)(6) of this section may be posted in lieu of labels so long as they contain information required for labeling. The employer shall ensure, to the extent feasible, that employees who come in contact with these signs or labels can comprehend them. Means to ensure employee comprehension may include the use of foreign languages, pictographs, graphics, and awareness training.

(9) Employee Information and Training

(i) The employer shall, at no cost to the employee, institute a training program for all employees who are likely to be exposed in excess of a PEL and for all employees who perform Class I through IV asbestos operations, and shall ensure their participation in the program.

(ii) Training shall be provided prior to or at the time of initial assignment and at least annually thereafter.

(iii) Training for Class I operations and for Class II operations that require the use of critical barriers (or equivalent isolation methods) and/or negative pressure enclosures under this section shall be the equivalent in curriculum, training method and length to the EPA Model Accreditation Plan (MAP) asbestos abatement workers training (40 CFR Part 763, subpart E, appendix C).

(iv) Training for other Class II work.

(A) For work with asbestos containing roofing materials, flooring materials, siding materials, ceiling tiles, or transite panels, training shall include at a minimum all the elements included in paragraph (k)(9)(viii) of this section and in addition, the specific work practices and engineering controls set forth in paragraph (g) of this section which specifically relate to that category. Such course shall include "hands-on" training and shall take at least 8 hours.

(B) An employee who works with more than one of the categories of material specified in paragraph (k)(9)(iv)(A) of this section shall receive training in the work practices applicable to each category of material that the employee removes and each removal method that the employee uses.

(C) For Class II operations not involving the categories of material specified in paragraph (k)(9)(iv)(A) of this section, training shall be provided which shall include at a minimum all the elements included in paragraph (k)(9)(viii) of this section and in addition, the specific work practices and engineering controls set forth in paragraph (g) of this section which specifically relate to the category of material being removed, and shall include "hands-on" training in the work practices applicable to each category of material that the employee removes and each removal method that the employee uses.

(v) Training for Class III employees shall be consistent with EPA requirements for training of local education agency maintenance and custodial staff as set forth at 40 CFR 763.92(a)(2). Such a course shall also include "hands-on" training and shall take at least 16 hours. Exception: For Class III operations for which the competent person determines that the EPA curriculum does not adequately cover the training needed to perform that activity, training shall include as a minimum all the elements included in paragraph (k)(9)(viii) of this section and in addition, the specific work practices and engineering controls set forth in paragraph (g) of this section which specifically relate to that activity, and shall include "hands-on" training in the work practices applicable to each category of material that the employee disturbs.

(vi) Training for employees performing Class IV operations shall be consistent with EPA requirements for training of local education agency maintenance and custodial staff as set forth at 40 CFR 763.92(a)(1). Such a course shall include available information concerning the locations of thermal system insulation and surfacing ACM/PACM, and asbestos-containing flooring material, or flooring material where the absence of asbestos has not yet been certified; and instruction in recognition of damage, deterioration, and delamination of asbestos containing building materials. Such course shall take at least 2 hours.

(vii) Training for employees who are likely to be exposed in excess of the PEL and who are not otherwise required to be trained under paragraph (k)(9)(iii) through (vi) of this section, shall meet the requirements of paragraph (k)(9)(viii) of this section.

(viii) The training program shall be conducted in a manner that the employee is able to understand. In addition to the content required by provisions in paragraphs (k)(9)(iii) through (vi) of this section, the employer shall ensure that each such employee is informed of the following:

(A) Methods of recognizing asbestos, including the requirement in paragraph (k)(1) of this section to presume that certain building materials contain asbestos;

(B) The health effects associated with asbestos exposure;

(C) The relationship between smoking and asbestos in producing lung cancer;

(D) The nature of operations that could result in exposure to asbestos, the importance of necessary protective controls to minimize exposure including, as applicable, engineering controls, work practices, respirators, housekeeping procedures, hygiene facilities, protective clothing, decontamination procedures, emergency procedures, and waste disposal procedures, and any necessary instruction in the use of these controls and procedures; where Class III and IV work will be or is performed, the contents of EPA 20T-2003, "Managing Asbestos In-Place" July 1990 or its equivalent in content;

(E) The purpose, proper use, fitting instructions, and limitations of respirators as required by 29 CFR 1910.134;

(F) The appropriate work practices for performing the asbestos job;

(G) Medical surveillance program requirements;

(H) The content of this standard including appendices;

(I) The names, addresses and phone numbers of public health organizations which provide information, materials and/or conduct programs concerning smoking cessation. The employer may distribute the list of such organizations contained in Appendix J to this section, to comply with this requirement; and

(J) The requirements for posting signs and affixing labels and the meaning of the required legends for such signs and labels.

(10) Access to training materials.

(i) The employer shall make readily available to affected employees without cost, written materials relating to the employee training program, including a copy of this regulation.

(ii) The employer shall provide to the Assistant Secretary and the Director, upon request, all information and training materials relating to the employee information and training program.

(iii) The employer shall inform all employees concerning the availability of self-help smoking cessation program material. Upon employee request, the employer shall distribute such material, consisting of NIH Publication No, 89-1647, or equivalent self-help material, which is approved or published by a public health organization listed in Appendix J to this section.

(l) Housekeeping

(1) Vacuuming

Where vacuuming methods are selected, HEPA filtered vacuuming equipment must be used. The equipment shall be used and emptied

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in a manner that minimizes the reentry of asbestos into the workplace.

(2) Waste disposal

Asbestos waste, scrap, debris, bags, containers, equipment, and contaminated clothing consigned for disposal shall be collected and disposed of in sealed, labeled, impermeable bags or other closed, labeled, impermeable containers except in roofing operations where the procedures specified in paragraph (g)(8)(ii) of this section apply.

(3) Care of asbestos-containing flooring material

(i) All vinyl and asphalt flooring material shall be maintained in accordance with this paragraph unless the building/facility owner demonstrates, pursuant to paragraph (g)(8)(i)(I) of this section that the flooring does not contain asbestos.

(ii) Sanding of flooring material is prohibited.

(iii) Stripping of finishes shall be conducted using low abrasion pads at speeds lower than 300 rpm and wet methods.

(iv) Burnishing or dry buffing may be performed only on flooring which has sufficient finish so that the pad cannot contact the flooring material.

(4) Waste and debris and accompanying dust in an area containing accessible thermal system insulation or surfacing ACM/PACM or visibly deteriorated ACM:

(i) shall not be dusted or swept dry, or vacuumed without using a HEPA filter;

(ii) shall be promptly cleaned up and disposed of in leak tight containers.

(m) Medical surveillance

(1) General

(i) Employees covered.

(A) The employer shall institute a medical surveillance program for all employees who for a combined total of 30 or more days per year are engaged in Class I, II and III work or are exposed at or above a permissible exposure limit. For purposes of this paragraph, any day in which a worker engages in Class II or Class III operations or a combination thereof on intact material for one hour or less (taking into account the entire time spent on the removal operation, including cleanup) and, while doing so, adheres fully to the work practices specified in this standard, shall not be counted.

(B) For employees otherwise required by this standard to wear a negative pressure respirator, employers shall ensure employees are physically able to perform the work and use the equipment. This determination shall be made under the supervision of a physician.

(ii) Examination.

(A) The employer shall ensure that all medical examinations and procedures are performed by or under the supervision of a licensed physician, and are provided at no cost to the employee and at a reasonable time and place.

(B) Persons other than such licensed physicians who administer the pulmonary function testing required by this section shall complete a training course in spirometry sponsored by an appropriate academic or professional institution.

(2) Medical examinations and consultations

(i) Frequency. The employer shall make available medical examinations and consultations to each employee covered under paragraph (m)(1)(i) of this section on the following schedules:

(A) Prior to assignment of the employee to an area where negative-pressure respirators are worn;

(B) When the employee is assigned to an area where exposure to asbestos may be at or above the permissible exposure limit for 30 or more days per year, or engage in Class I, II, or III work for a combined total of 30 or more days per year, a medical examination must be given within 10 working days following the thirtieth day of exposure;

(C) And at least annually thereafter.

(D) If the examining physician determines that any of the examinations should be provided more frequently than specified, the employer shall provide such examinations to affected employees at the frequencies specified by the physician.

(E) Exception: No medical examination is required of any employee if adequate records show that the employee has been examined in accordance with this paragraph within the past 1-year period.

(ii) Content. Medical examinations made available pursuant to paragraphs (m)(2)(i)(A) through (m)(2)(i)(C) of this section shall include:

(A) A medical and work history with special emphasis directed to the pulmonary, cardiovascular, and gastrointestinal systems.

(B) On initial examination, the standardized questionnaire contained in Part 1 of Appendix D to this section, and, on annual examination, the abbreviated standardized questionnaire contained in Part 2 of Appendix D to this section.

(C) A physical examination directed to the pulmonary and gastrointestinal systems, including a chest roentgenogram to be administered at the discretion of the physician, and pulmonary function tests of forced vital capacity (FVC) and forced expiratory volume at one second (FEV_1). Interpretation and classification of chest shall be conducted in accordance with Appendix E to this section.

(D) Any other examinations or tests deemed necessary by the examining physician.

(3) Information provided to the physician.

The employer shall provide the following information to the examining physician:

(i) A copy of this standard and Appendices D, E, and I to this section;

(ii) A description of the affected employee's duties as they relate to the employee's exposure;

(iii) The employee's representative exposure level or anticipated exposure level;

(iv) A description of any personal protective and respiratory equipment used or to be used; and

(v) Information from previous medical examinations of the affected employee that is not otherwise available to the examining physician.

(4) Physician's written opinion.

(i) The employer shall obtain a written opinion from the examining physician. This written opinion shall contain the results of the medical examination and shall include:

(A) The physician's opinion as to whether the employee has any detected medical conditions that would place the employee at an increased risk of material health impairment from exposure to asbestos;

(B) Any recommended limitations on the employee or on the use of personal protective equipment such as respirators; and

(C) A statement that the employee has been informed by the physician of the results of the medical examination and of any medical conditions that may result from asbestos exposure.

(D) A statement that the employee has been informed by the physician of the increased risk of lung cancer attributable to the combined effect of smoking and asbestos exposure.

(ii) The employer shall instruct the physician not to reveal in the written opinion given to the employer specific findings or diagnoses unrelated to occupational exposure to asbestos.

(iii) The employer shall provide a copy of the physician's written opinion to the affected employee within 30 days from its receipt.

(n) Recordkeeping

(1) Objective data relied on pursuant to paragraph (f) to this section.

(i) Where the employer has relied on objective data that demonstrates that products made from or containing asbestos or the activity involving such products or material are not capable of releasing fibers of asbestos in concentrations at or above the permissible exposure limit and/or excursion limit under the expected conditions of processing, use, or handling to satisfy the requirements of paragraph (f), the employer shall establish and maintain an accurate record of objective data reasonably relied upon in support of the exemption.

(ii) The record shall include at least the following information:

(A) The product qualifying for exemption;

(B) The source of the objective data;

(C) The testing protocol, results of testing, and/or analysis of the material for the release of asbestos;

(D) A description of the operation exempted and how the data support the exemption; and

(E) Other data relevant to the operations, materials, processing, or employee exposures covered by the exemption.

(iii) The employer shall maintain this record for the duration of the employer's reliance upon such objective data.

(2) Exposure measurements.

(i) The employer shall keep an accurate record of all measurements taken to monitor employee exposure to asbestos as prescribed in paragraph (f) of this section. NOTE: The employer may utilize the services of competent organizations such as industry trade associations and employee associations to maintain the records required by this section.

(ii) This record shall include at least the following information:

(A) The date of measurement;

(B) The operation involving exposure to asbestos that is being monitored;

(C) Sampling and analytical methods used and evidence of their accuracy;

(D) Number, duration, and results of samples taken;

(E) Type of protective devices worn, if any; and

(F) Name, social security number, and exposure of the employees whose exposures are represented.

(iii) The employer shall maintain this record for at least thirty (30) years, in accordance with 29 CFR 1910.20.

(3) Medical surveillance.

(i) The employer shall establish and maintain an accurate record for each employee subject to medical surveillance by paragraph (m) of this section, in accordance with 29 CFR 1910.20.

(ii) The record shall include at least the following information:

(A) The name and social security number of the employee;

(B) A copy of the employee's medical examination results, including the medical history, questionnaire responses, results of any tests, and physician's recommendations.

(C) Physician's written opinions;

(D) Any employee medical complaints related to exposure to asbestos; and

(E) A copy of the information provided to the physician as required by paragraph (m) of this section.

(iii) The employer shall ensure that this record is maintained for the duration of employment plus thirty (30) years, in accordance with 29 CFR 1910.20.

(4) Training records.

The employer shall maintain all employee training records for one (1) year beyond the last date of employment by that employer.

(5) Data to Rebut PACM.

Where the building owner and employer have relied on data to demonstrate that PACM is not asbestos-containing, such data shall be maintained for as long as they are relied upon to rebut the presumption.

(6) Records of Required Notifications.

Where the building owner has communicated and received information concerning the identification, location and quantity of ACM and PACM, written records of such notifications and their content shall be maintained by the building owner for the duration of ownership and shall be transferred to successive owners of such buildings/facilities.

(7) Availability.

(i) The employer, upon written request, shall make all records required to be maintained by this section available to the Assistant Secretary and the Director for examination and copying.

(ii) The employer, upon request, shall make any exposure records required by paragraphs (f) and (n) of this section available for examination and copying to affected employees, former employees, designated representatives, and the Assistant Secretary, in accordance with 29 CFR 1910.20(a) through (e) and (g) through (i).

(iii) The employer, upon request, shall make employee medical records required by paragraphs (m) and (n) of this section available for examination and copying to the subject employee, anyone having the specific written consent of the subject employee, and the Assistant Secretary, in accordance with 29 CFR 1910.20.

(8) Transfer of records.

(i) The employer shall comply with the requirements concerning transfer of records set forth in 29 CFR 1910.20(h).

(ii) Whenever the employer ceases to do business and there is no successor employer to receive and retain the records for the prescribed period, the employer shall notify the Director at least 90 days prior to disposal and, upon request, transmit them to the Director.

(o) Competent person.

(1) General.

On all construction worksites covered by this standard, the employer shall designate a competent person, having the qualifications and authorities for ensuring worker safety and health required by Subpart C, General Safety and Health Provisions for Construction (29 CFR 1926.20 through 1926.32).

(2) Required Inspections by the Competent Person.

Section 1926.20(b)(2) which requires health and safety prevention programs to provide for frequent and regular inspections of the job sites, materials, and equipment to be made by competent persons, is incorporated.

(3) Additional Inspections.

In addition, the competent person shall make frequent and regular inspections of the job sites, in order to perform the duties set out below in paragraph (o)(3)(i) and (ii) of this section. For Class I jobs, on-site inspections shall be made at least once during each work shift, and at any time at employee request. For Class II, III, and IV jobs, on-site inspections shall be made at intervals sufficient to assess whether conditions have changed, and at any reasonable time at employee request.

(i) On all worksites where employees are engaged in Class I or II asbestos work, the competent person designated in accordance with paragraph (e)(6) of this section shall perform or supervise the following duties, as applicable:

(A) Set up the regulated area, enclosure, or other containment;

(B) Ensure (by on-site inspection) the integrity of the enclosure or containment;

(C) Set up procedures to control entry to and exit from the enclosure and/or area;

(D) Supervise all employee exposure monitoring required by this section and ensure that it is conducted as required by paragraph (f) of this section;

(E) Ensure that employees working within the enclosure and/or using glove bags wear respirators and protective clothing as required by paragraphs (h) and (i) of this section;

(F) Ensure through on-site supervision, that employees set up, use and remove engineering controls, use work practices and personal protective equipment in compliance with all requirements;

(G) Ensure that employees use the hygiene facilities and observe the decontamination procedures specified in paragraph (j) of this section;

(H) Ensure that through on-site inspection, engineering controls are functioning properly and employees are using proper work practices; and,

(I) Ensure that notification requirement in paragraph (k) of this section are met.

(ii) [Reserved]

(4) Training for the competent person.

(i) For Class I and II asbestos work the competent person shall be trained in all aspects of asbestos removal and handling, including: abatement, installation, removal and handling; the contents of this standard; the identification of asbestos; removal procedures, where appropriate; and other practices for reducing the hazard. Such training shall be obtained in a comprehensive course for supervisors that meets the criteria of EPA's Model Accredited Plan (40 CFR part 763, subpart E, Appendix C), such as a course conducted by an EPA-approved or state-approved training provider, certified by EPA or a state, or a course equivalent in stringency, content, and length.

(ii) For Class III and IV asbestos work, the competent person shall be trained in aspects of asbestos handling appropriate for the nature of the work, to include procedures for setting up glove bags and mini-enclosures, practices for reducing asbestos exposures, use of wet methods, the contents of this standard, and the identification of asbestos. Such training shall include successful completion of a course that is consistent with EPA requirements for training of local education agency maintenance and custodial staff as set forth at 40 CFR 763.92(a)(2), or its equivalent in stringency, content, and length. Competent persons for Class III and IV work, may also be trained pursuant to the requirements of paragraph (o)(4)(i) of this section.

(p) Appendices.

(1) Appendices A, C, D, and E to this section are incorporated as part of this section and the contents of these appendices are mandatory.

(2) Appendices B, F, H, I, J, and K to this section are informational and are not intended to create any additional obligations not otherwise imposed or to detract from any existing obligations.

(q) Dates.

(1) This standard shall become effective October 11, 1994.

(2) The provisions of 29 CFR 1926.58 remain in effect until the start-up dates of the equivalent provisions of this standard.

(3) Start-up dates. All obligations of this standard commence on the effective date except as follows:

(i) Methods of compliance. The engineering and work practice controls required by paragraph (g) of this section shall be implemented by October 1, 1995.

(ii) Respiratory protection. Respiratory protection required by paragraph (h) of this section shall be provided by October 1, 1995.

(iii) Hygiene facilities and practices for employees. Hygiene facilities and practices required by paragraph (j) of this section shall be provided by October 1, 1995.

(iv) Communication of hazards. Identification, notification, labeling and sign posting, and training required by paragraph (k) of this section shall be provided by October 1, 1995.

(v) Housekeeping. Housekeeping practices and controls required by paragraph (1) of this section shall be provided by October 1, 1995.

(vi) Medical surveillance required by paragraph (m) of this section shall be provided by October 1, 1995.

(vii) The designation and training of competent persons required by paragraph (o) of this section shall be completed by October 1, 1995.

[59 FR 40964, Aug. 10, 1994; 60 FR 9624, Feb. 21, 1995; 60 FR 33343, June 28, 1995; 60 FR 33972, June 29, 1995; 60 FR 36043, July 13, 1995; 60 FR 50411, Sept. 29, 1995; 61 FR 5507, Feb. 13, 1996; 61 FR 43454, August 23, 1996; 63 FR 1152, Jan. 8, 1998; 63 FR 20098, April 23, 1998; 63 FR 35138, June 29, 1998]

Appendix A to 29 CFR 1926.1101
OSHA Reference Method - Mandatory -

This mandatory appendix specifies the procedure for analyzing air samples for asbestos and specifies quality control procedures that must be implemented by laboratories performing the analysis. The sampling and analytical methods described below represent the elements of the available monitoring methods (such as Appendix B of this regulation, the most current version of the OSHA method ID-160, or the most current version of the NIOSH Method 7400). All employers who are required to conduct air monitoring under paragraph (f) of the standard are required to utilize analytical laboratories that use this procedure, or an equivalent method, for collecting and analyzing samples.

Sampling and Analytical Procedure

1. The sampling medium for air samples shall be mixed cellulose ester filter membranes. These shall be designated by the manufacturer as suitable for asbestos counting. See below for rejection of blanks.
2. The preferred collection device shall be the 25-mm diameter cassette with an open-faced 50-mm electrically conductive extension cowl. The 37-mm cassette may be used if necessary but only if written justification for the need to use the 37-mm filter cassette accompanies the sample results in the employee's exposure monitoring record. Do not reuse or reload cassettes for asbestos sample collection.
3. An air flow rate between 0.5 liter/min and 2.5 liters/min shall be selected for the 25/mm cassette. If the 37-mm cassette is used, an air flow rate between 1 liter/min and 2.5 liters/min shall be selected.
4. Where possible, a sufficient air volume for each air sample shall be collected to yield between 100 and 1,300 fibers per square millimeter on the membrane filter. If a filter darkens in appearance or if loose dust is seen on the filter, a second sample shall be started.
5. Ship the samples in a rigid container with sufficient packing material to prevent dislodging the collected fibers. Packing material that has a high electrostatic charge on its surface (e.g., expanded polystyrene) cannot be used because such material can cause loss of fibers to the sides of the cassette.
6. Calibrate each personal sampling pump before and after use with a representative filter cassette installed between the pump and the calibration devices.
7. Personal samples shall be taken in the "breathing zone" of the employee (i.e., attached to or near the collar or lapel near the worker's face).
8. Fiber counts shall be made by positive phase contrast using a microscope with an 8 to 10 X eyepiece and a 40 to 45 X objective for a total magnification of approximately 400 X

and a numerical aperture of 0.65 to 0.75. The microscope shall also be fitted with a green or blue filter.

9. The microscope shall be fitted with a Walton-Beckett eyepiece graticule calibrated for a field diameter of 100 micrometers (+/- 2 micrometers).

10. The phase-shift detection limit of the microscope shall be about 3 degrees measured using the HSE phase shift test slide as outlined below.

a. Place the test slide on the microscope stage and center it under the phase objective.
b. Bring the blocks of grooved lines into focus.

Note: The slide consists of seven sets of grooved lines (ca. 20 grooves to each block) in descending order of visibility from sets 1 to 7, seven being the least visible. The requirements for asbestos counting are that the microscope optics must resolve the grooved lines in set 3 completely, although they may appear somewhat faint, and that the grooved lines in sets 6 and 7 must be invisible. Sets 4 and 5 must be at least partially visible but may vary slightly in visibility between microscopes. A microscope that fails to meet these requirements has either too low or too high a resolution to be used for asbestos counting.

c. If the image deteriorates, clean and adjust the microscope optics. If the problem persists, consult the microscope manufacturer.

11. Each set of samples taken will include 10% field blanks or a minimum of 2 field blanks. These blanks must come from the same lot as the filters used for sample collection. The field blank results shall be averaged and subtracted from the analytical results before reporting. A set consists of any sample or group of samples for which an evaluation for this standard must be made. Any samples represented by a field blank having a fiber count in excess of the detection limit of the method being used shall be rejected.

12. The samples shall be mounted by the acetone/triacetin method or a method with an equivalent index of refraction and similar clarity.

13. Observe the following counting rules.

a. Count only fibers equal to or longer than 5 micrometers. Measure the length of curved fibers along the curve.

b. In the absence of other information, count all particles as asbestos that have a length-to-width ratio (aspect ratio) of 3:1 or greater.

c. Fibers lying entirely within the boundary of the Walton-Beckett graticule field shall receive a count of 1. Fibers crossing the boundary once, having one end within the circle, shall receive the count of one half (1/2). Do not count any fiber that crosses the graticule boundary more than once. Reject and do not count any other fibers even though they may be visible outside the graticule area.

d. Count bundles of fibers as one fiber unless individual fibers can be identified by observing both ends of an individual fiber.

e. Count enough graticule fields to yield 100 fibers. Count a minimum of 20 fields; stop counting at 100 fields regardless of fiber count.

14. Blind recounts shall be conducted at the rate of 10 percent.

Quality Control Procedures

1. Intralaboratory program. Each laboratory and/or each company with more than one microscopist counting slides shall establish a statistically designed quality assurance program involving blind recounts and comparisons between microscopists to monitor the variability of counting by each microscopist and between microscopists. In a company with more than one laboratory, the program shall include all laboratories, and shall also evaluate the laboratory-to-laboratory variability.

2.a. Interlaboratory program. Each laboratory analyzing asbestos samples for compliance determination shall implement an interlaboratory quality assurance program that, as a minimum, includes participation of at least two other independent laboratories. Each laboratory shall participate in round robin testing at least once every 6 months with at least all the other laboratories in its interlaboratory quality assurance group. Each laboratory shall submit slides typical of its own workload for use in this program. The round robin shall be designed and results analyzed using appropriate statistical methodology.

2.b. All laboratories should also participate in a national sample testing scheme such as the Proficiency Analytical Testing Program (PAT), or the Asbestos Registry sponsored by the American Industrial Hygiene Association (AIHA).

3. All individuals performing asbestos analysis must have taken the NIOSH course for sampling and evaluating airborne asbestos dust or an equivalent course.

4. When the use of different microscopes contributes to differences between counters and laboratories, the effect of the different microscope shall be evaluated and the microscope shall be replaced, as necessary.

5. Current results of these quality assurance programs shall be posted in each laboratory to keep the microscopists informed.

[Appendix A to § 1926.1101 revised at 59 FR 41144, Aug. 10, 1994, effective Oct. 11, 1994.]

Appendix B to § 1926.1101
Sampling and Analysis - Non-mandatory

Air

Matrix:

OSHA Permissible Exposure Limits:
Time Weighted Average . . . . . 0.1 fiber/cc
Excursion Level (30 minutes) . . . . . 1.0 fiber/cc

Collection Procedure:

A known volume of air is drawn through a 25mm diameter cassette containing a mixed-cellulose ester filter. The cassette must be equipped with an electrically conductive 50mm extension cowl. The sampling time and rate are chosen to give a fiber density of between 100 to 1,300 fibers/mm^2 on the filter.

Recommended Sampling Rate . . . . . 0.5 to 5.0 liters/minute (L/min)

Recommended Air Volumes:
Minimum . . . . . 25 L
Maximum . . . . . 2,400 L

Analytical Procedure

A portion of the sample filter is cleared and prepared for asbestos fiber counting by Phase Contrast Microscopy (PCM) at 400X.

Commercial manufacturers and products mentioned in this method are for descriptive use only and do not constitute endorsements by USDOL-OSHA. Similar products from other sources can be substituted.

1. Introduction

This method describes the collection of airborne asbestos fibers using calibrated sampling pumps with mixed-cellulose ester (MCE) filters and analysis by phase contrast microscopy (PCM). Some terms used are unique to this method and are defined below:

Asbestos: A term for naturally occurring fibrous minerals. Asbestos includes chrysotile, crocidolite, amosite (cummingtonite-grunerite asbestos), tremolite asbestos, actinolite asbestos, anthophyllite asbestos, and any of these minerals that have been chemically treated and/or altered. The precise chemical formulation of each species will vary with the location from which it was mined. Nominal compositions are listed:

Chrysotile: $Mg_3Si_2O_5(OH)_4$
Crocidolite: $Na_2Fe_3^{2+}Fe_2^{3+}Si_8O_{22}(OH)_2$
Amosite: $(Mg,Fe)_7Si_8O_{22}(OH)_2$
Tremolite-actinolite: $Ca_2(Mg,Fe)_5Si_8O_{22}(OH)_2$
Anthophyllite: $(Mg,Fe)_7Si_8O_{22}(OH)_2$

Asbestos Fiber: A fiber of asbestos which meets the criteria specified below for a fiber.

Aspect Ratio: The ratio of the length of a fiber to it's diameter (e.g. 3:1, 5:1 aspect ratios).

Cleavage Fragments: Mineral particles formed by comminution of minerals, especially those characterized by parallel sides and a moderate aspect ratio (usually less than 20:1).

Detection Limit: The number of fibers necessary to be 95% certain that the result is greater than zero.

Differential Counting: The term applied to the practice of excluding certain kinds of fibers from the fiber count because they do not appear to be asbestos.

Fiber: A particle that is 5 µm or longer, with a length-to-width ratio of 3 to 1 or longer.

Field: The area within the graticule circle that is superimposed on the microscope image.

Set: The samples which are taken, submitted to the laboratory, analyzed, and for which, interim or final result reports are generated.

Tremolite, Anthophyllite, and Actinolite: The non-asbestos form of these minerals which meet the definition of a fiber. It includes any of these minerals that have been chemically treated and/or altered.

Walton-Beckett Graticule: An eyepiece graticule specifically designed for asbestos fiber counting. It consists of a circle with a projected diameter of 100 plus or minus 2 um (area of about 0.00785 mm(2)) with a crosshair having tic-marks at 3-um intervals in one direction and 5-um in the orthogonal direction. There are marks around the periphery of the circle to demonstrate the proper sizes and shapes of fibers. This design is reproduced in Figure 1. The disk is placed in one of the microscope eyepieces so that the design is superimposed on the field of view.

1.1. History

Early surveys to determine asbestos exposures were conducted using impinger counts of total dust with the counts expressed as million particles per cubic foot. The British Asbestos Research Council recommended filter membrane counting in 1969. In July 1969, the Bureau of Occupational Safety and Health published a filter membrane method for counting asbestos fibers in the United States. This method was refined by NIOSH and published as P & CAM 239. On May 29, 1971, OSHA specified filter membrane sampling with phase contrast counting for evaluation of asbestos exposures at work sites in the United States. The use of this technique was again required by OSHA in 1986. Phase contrast microscopy has continued to be the method of choice for the measurement of occupational exposure to asbestos.

1.2. Principle

Air is drawn through a MCE filter to capture airborne asbestos fibers. A wedge shaped portion of the filter is removed, placed on a glass microscope slide and made transparent. A measured area (field) is viewed by PCM. All the fibers meeting defined criteria for asbestos are counted and considered a measure of the airborne asbestos concentration.

1.3. Advantages and Disadvantages

There are four main advantages of PCM over other methods:

(1) The technique is specific for fibers. Phase contrast is a fiber counting technique which excludes non-fibrous particles from the analysis.

(2) The technique is inexpensive and does not require specialized knowledge to carry out the analysis for total fiber counts.

(3) The analysis is quick and can be performed on-site for rapid determination of air concentrations of asbestos fibers.

(4) The technique has continuity with historical epidemiological studies so that estimates of expected disease can be inferred from long-term determinations of asbestos exposures.

The main disadvantage of PCM is that it does not positively identify asbestos fibers. Other fibers which are not asbestos may be included in the count unless differential counting is performed. This requires a great deal of experience to adequately differentiate asbestos from non-asbestos fibers. Positive identification of asbestos must be performed by polarized light or electron microscopy techniques. A further disadvantage of PCM is that the smallest visible fibers are about 0.2 um in diameter while the finest asbestos fibers may be as small as 0.02 um in diameter. For some exposures, substantially more fibers may be present than are actually counted.

1.4. Workplace Exposure

Asbestos is used by the construction industry in such products as shingles, floor tiles, asbestos cement, roofing felts, insulation and acoustical products. Non-construction uses include brakes, clutch facings, paper, paints, plastics, and fabrics. One of the most significant exposures in the workplace is the removal and encapsulation of asbestos in schools, public buildings, and homes. Many workers have the potential to be exposed to asbestos during these operations.

About 95% of the asbestos in commercial use in the United States is chrysotile. Crocidolite and amosite make up most of the remainder. Anthophyllite and tremolite or actinolite are likely to be encountered as contaminants in various industrial products.

1.5. Physical Properties

Asbestos fiber possesses a high tensile strength along its axis, is chemically inert, non-combustible, and heat resistant. It has a high electrical resistance and good sound absorbing properties. It can be weaved into cables, fabrics or other textiles, and also matted into asbestos papers, felts, or mats.

2. Range and Detection Limit

2.1. The ideal counting range on the filter is 100 to 1,300 fibers/mm(2). With a Walton-Beckett graticule this range is equivalent to 0.8 to 10 fibers/field. Using NIOSH counting statistics, a count of 0.8 fibers/field would give an approximate coefficient of variation (CV) of 0.13.

2.2. The detection limit for this method is 4.0 fibers per 100 fields or 5.5 fibers/mm(2). This was determined using an equation to estimate the maximum CV possible at a specific concentration (95% confidence) and a Lower Control Limit of zero. The CV value was then used to determine a corresponding concentration from historical CV vs fiber relationships. As an example:

Lower Control Limit (95% Confidence)
= AC -- 1.645(CV)(AC)

Where:

AC = Estimate of the airborne fiber concentration (fibers/cc). Setting the Lower Control Limit = 0 and solving for CV:

0 = AC -- 1.645(CV)(AC)
CV = 0.61

This value was compared with CV vs. count curves. The count at which CV = 0.61 for Leidel-Busch counting statistics or for an OSHA Salt Lake Technical Center (OSHA-SLTC) CV curve (see Appendix A for further information) was 4.4 fibers or 3.9 fibers per 100 fields, respectively. Although a lower detection limit of 4 fibers per 100 fields is supported by the OSHA-SLTC data, both data sets support the 4.5 fibers per 100 fields value.

3. Method Performance – Precision and Accuracy

Precision is dependent upon the total number of fibers counted and the uniformity of the fiber distribution on the filter. A general rule is to count at least 20 and not more than 100 fields. The count is discontinued when 100 fibers are counted, provided that 20 fields have already been counted. Counting more than 100 fibers results in only a small gain in precision. As the total count drops below 10 fibers, an accelerated loss of precision is noted.

At this time, there is no known method to determine the absolute accuracy of the asbestos analysis. Results of samples prepared through the Proficiency Analytical Testing (PAT) Program and analyzed by the OSHA-SLTC showed no significant bias when compared to PAT reference values. The PAT samples were analyzed from 1987 to 1989 (N = 36) and the concentration range was from 120 to 1,300 fibers/mm(2).

4. Interferences

Fibrous substances, if present, may interfere with asbestos analysis.

Some common fibers are:

Fiberglass
Anhydrite

Plant Fibers
Perlite Veins
Gypsum
Some Synthetic Fibers
Membrane Structures
Sponge Spicules
Diatoms
Microorganisms
Wollastonite

The use of electron microscopy or optical tests such as polarized light, and dispersion staining may be used to differentiate these materials from asbestos when necessary.

5. Sampling

5.1. Equipment

5.1.1. Sample assembly (The assembly is shown in Figure 3). Conductive filter holder consisting of a 25-mm diameter, 3-piece cassette having a 50-mm long electrically conductive extension cowl. Backup pad, 25-mm, cellulose. Membrane filter, mixed-cellulose ester (MCE), 25-mm, plain, white, 0.4 to 1.2-um pore size.

Notes:

(a) DO NOT RE-USE CASSETTES.

(b) Fully conductive cassettes are required to reduce fiber loss to the sides of the cassette due to electrostatic attraction.

(c) Purchase filters which have been selected by the manufacturer for asbestos counting or analyze representative filters for fiber background before use. Discard the filter lot if more than 4 fibers/ 100 fields are found.

(d) To decrease the possibility of contamination, the sampling system (filter-backup pad-cassette) for asbestos is usually preassembled by the manufacturer.

(e) Other cassettes, such as the Bell-mouth, may be used within the limits of their validation.

5.1.2. Gel bands for sealing cassettes.

5.1.3. Sampling pump.

Each pump must be a battery operated, self-contained unit small enough to be placed on the monitored employee and not interfere with the work being performed. The pump must be capable of sampling at the collection rate for the required sampling time.

5.1.4. Flexible tubing, 6-mm bore.

5.1.5. Pump calibration.

Stopwatch and bubble tube/burette or electronic meter.

5.2. Sampling Procedure

5.2.1. Seal the point where the base and cowl of each cassette meet with a gel band or tape.

5.2.2. Charge the pumps completely before beginning.

5.2.3. Connect each pump to a calibration cassette with an appropriate length of 6-mm bore plastic tubing. Do not use luer connectors -- the type of cassette specified above has built-in adapters.

5.2.4. Select an appropriate flow rate for the situation being monitored. The sampling flow rate must be between 0.5 and 5.0 L/min for personal sampling and is commonly set between 1 and 2 L/min. Always choose a flow rate that will not produce overloaded filters.

5.2.5. Calibrate each sampling pump before and after sampling with a calibration cassette in-line (Note: This calibration cassette should be from the same lot of cassettes used for sampling). Use a primary standard (e.g. bubble burette) to calibrate each pump. If possible, calibrate at the sampling site.

Note: If sampling site calibration is not possible, environmental influences may affect the flow rate. The extent is dependent on the type of pump used. Consult with the pump manufacturer to determine dependence on environmental influences. If the pump is affected by temperature and pressure changes, correct the flow rate using the formula shown in the section “Sampling Pump Flow Rate Corrections” at the end of this appendix.

5.2.6. Connect each pump to the base of each sampling cassette with flexible tubing. Remove the end cap of each cassette and take each air sample open face. Assure that each sample cassette is held open side down in the employee’s breathing zone during sampling. The distance from the nose/mouth of the employee to the cassette should be about 10 cm. Secure the cassette on the collar or lapel of the employee using spring clips or other similar devices.

5.2.7. A suggested minimum air volume when sampling to determine TWA compliance is 25 L. For Excursion Limit (30 min sampling time) evaluations, a minimum air volume of 48 L is recommended.

5.2.8. The most significant problem when sampling for asbestos is overloading the filter with non-asbestos dust. Suggested maximum air sample volumes for specific environments are:

Environment	Air Vol. (L)
Asbestos removal operations (visible dust)	100
Asbestos removal operations (little dust)	240
Office environments	400 to 2,400

CAUTION: Do not overload the filter with dust. High levels of non-fibrous dust particles may obscure fibers on the filter and lower the count or make counting impossible. If more than about 25 to 30% of the field area is obscured with dust, the result may be biased low. Smaller air volumes may be necessary when there is excessive non-asbestos dust in the air.

While sampling, observe the filter with a small flashlight. If there is a visible layer of dust on the filter, stop sampling, remove and seal the cassette, and replace with a new sampling assembly. The total dust loading should not exceed 1 mg.

5.2.9. Blank samples are used to determine if any contamination has occurred during sample handling. Prepare two blanks for the first 1 to 20 samples. For sets containing greater than 20 samples, prepare blanks as 10% of the samples. Handle blank samples in the same manner as air samples with one exception: Do not draw any air through the blank samples. Open the blank cassette in the place where the sample cassettes are mounted on the employee. Hold it open for about 30 seconds. Close and seal the cassette appropriately. Store blanks for shipment with the sample cassettes.

5.2.10. Immediately after sampling, close and seal each cassette with the base and plastic plugs. Do not touch or puncture the filter membrane as this will invalidate the analysis.

5.2.11. Attach and secure a sample seal around each sample cassette in such a way as to assure that the end cap and base plugs cannot be removed without destroying the seal. Tape the ends of the seal together since the seal is not long enough to be wrapped end-to-end. Also wrap tape around the cassette at each joint to keep the seal secure.

5.3. Sample Shipment

5.3.1. Send the samples to the laboratory with paperwork requesting asbestos analysis. List any known fibrous interferences present during sampling on the paperwork. Also, note the workplace operation(s) sampled.

5.3.2. Secure and handle the samples in such that they will not rattle during shipment nor be exposed to static electricity. Do not ship samples in expanded polystyrene peanuts, vermiculite, paper shreds, or excelsior. Tape sample cassettes to sheet bubbles and place in a container that will cushion the samples in such a manner that they will not rattle.

5.3.3. To avoid the possibility of sample contamination, always ship bulk samples in separate mailing containers.

6. Analysis

6.1. Safety Precautions

6.1.1. Acetone is extremely flammable and precautions must be taken not to ignite it. Avoid using large containers or quantities of acetone. Transfer the solvent in a ventilated laboratory hood. Do not use acetone near any open flame. For generation of acetone vapor, use a spark free heat source.

6.1.2. Any asbestos spills should be cleaned up immediately to prevent dispersal of fibers. Prudence should be exercised to avoid contamination of laboratory facilities or exposure of personnel to asbestos. Asbestos spills should be cleaned up with wet methods and/ or a High Efficiency Particulate-Air (HEPA) filtered vacuum.

CAUTION: Do not use a vacuum without a HEPA filter -- It will disperse fine asbestos fibers in the air.

6.2. Equipment

6.2.1. Phase contrast microscope with binocular or trinocular head.

6.2.2. Widefield or Huygenian 10X eyepieces (NOTE: The eyepiece containing the graticule must be a focusing eyepiece. Use a 40X phase objective with a numerical aperture of 0.65 to 0.75).

6.2.3. Kohler illumination (if possible) with green or blue filter.

6.2.4. Walton-Beckett Graticule, type G-22 with 100 plus or minus 2 um projected diameter.

6.2.5. Mechanical stage. A rotating mechanical stage is convenient for use with polarized light.

6.2.6. Phase telescope.

6.2.7. Stage micrometer with 0.01-mm subdivisions.

6.2.8. Phase-shift test slide, mark II (Available from PTR optics Ltd., and also McCrone).

6.2.9. Precleaned glass slides, 25 mm X 75 mm. One end can be frosted for convenience in writing sample numbers, etc., or paste-on labels can be used.

6.2.10. Cover glass #1 1/2.

6.2.11. Scalpel (#10, curved blade).

6.2.12. Fine tipped forceps.

6.2.13. Aluminum block for clearing filter (see Appendix D and Figure 4).

6.2.14. Automatic adjustable pipette, 100- to 500-uL.

6.2.15. Micropipette, 5 uL.

6.3. Reagents

6.3.1. Acetone (HPLC grade).

6.3.2. Triacetin (glycerol triacetate).

6.3.3. Lacquer or nail polish.

6.4. Standard Preparation

A way to prepare standard asbestos samples of known concentration has not been developed. It is possible to prepare replicate samples of nearly equal concentration. This has been performed through the PAT program. These asbestos samples are distributed by the AIHA to participating laboratories.

Since only about one-fourth of a 25-mm sample membrane is required for an asbestos count, any PAT sample can serve as a "standard" for replicate counting.

6.5. Sample Mounting

Note: See Safety Precautions in Section 6.1. before proceeding. The objective is to produce samples with a smooth (non-grainy) background in a medium with a refractive index of approximately 1.46. The technique below collapses the filter for easier focusing and produces permanent mounts which are useful for quality control and interlaboratory comparison.

An aluminum block or similar device is required for sample preparation.

6.5.1. Heat the aluminum block to about 70 deg.C. The hot block should not be used on any surface that can be damaged by either the heat or from exposure to acetone.

6.5.2. Ensure that the glass slides and cover glasses are free of dust and fibers.

6.5.3. Remove the top plug to prevent a vacuum when the cassette is opened. Clean the outside of the cassette if necessary. Cut the seal and/or tape on the cassette with a razor blade. Very carefully separate the base from the extension cowl, leaving the filter and backup pad in the base.

6.5.4. With a rocking motion cut a triangular wedge from the filter using the scalpel. This wedge should be one-sixth to one-fourth of the filter. Grasp the filter wedge with the forceps on the perimeter of the filter which was clamped between the cassette pieces. DO NOT TOUCH the filter with your finger. Place the filter on the glass slide sample side up. Static electricity will usually keep the filter on the slide until it is cleared.

6.5.5. Place the tip of the micropipette containing about 200 uL acetone into the aluminum block. Insert the glass slide into the receiving slot in the aluminum block. Inject the acetone into the block with slow, steady pressure on the plunger while holding the pipette firmly in place. Wait 3 to 5 seconds for the filter to clear, then remove the pipette and slide from the aluminum block.

6.5.6. Immediately (less than 30 seconds) place 2.5 to 3.5 uL of triacetin on the filter (NOTE: Waiting longer than 30 seconds will result in increased index of refraction and decreased contrast between the fibers and the preparation. This may also lead to separation of the cover slip from the slide).

6.5.7. Lower a cover slip gently onto the filter at a slight angle to reduce the possibility of forming air bubbles. If more than 30 seconds have elapsed between acetone exposure and triacetin application, glue the edges of the cover slip to the slide with lacquer or nail polish.

6.5.8. If clearing is slow, warm the slide for 15 min on a hot plate having a surface temperature of about 50 deg.C to hasten clearing. The top of the hot block can be used if the slide is not heated too long.

6.5.9. Counting may proceed immediately after clearing and mounting are completed.

6.6. Sample Analysis

Completely align the microscope according to the manufacturer's instructions. Then, align the microscope using the following general alignment routine at the beginning of every counting session and more often if necessary.

6.6.1. Alignment

(1) Clean all optical surfaces. Even a small amount of dirt can significantly degrade the image.

(2) Rough focus the objective on a sample.

(3) Close down the field iris so that it is visible in the field of view. Focus the image of the iris with the condenser focus. Center the image of the iris in the field of view.

(4) Install the phase telescope and focus on the phase rings. Critically center the rings. Misalignment of the rings results in astigmatism which will degrade the image.

(5) Place the phase-shift test slide on the microscope stage and focus on the lines. The analyst must see line set 3 and should see at least parts of 4 and 5 but, not see line set 6 or 6. A microscope/microscopist combination which does not pass this test may not be used.

6.6.2. Counting Fibers

(1) Place the prepared sample slide on the mechanical stage of the microscope. Position the center of the wedge under the objective lens and focus upon the sample.

(2) Start counting from one end of the wedge and progress along a radial line to the other end (count in either direction from perimeter to wedge tip). Select fields randomly, without looking into the eyepieces, by slightly advancing the slide in one direction with the mechanical stage control.

(3) Continually scan over a range of focal planes (generally the upper 10 to 15 um of the filter surface) with the fine focus control during each field count. Spend at least 5 to 15 seconds per field.

(4) Most samples will contain asbestos fibers with fiber diameters less than 1 um. Look carefully for faint fiber images. The small diameter fibers will be very hard to see. However, they are an important contribution to the total count.

(5) Count only fibers equal to or longer than 5 um. Measure the length of curved fibers along the curve.

(6) Count fibers which have a length to width ratio of 3:1 or greater.

(7) Count all the fibers in at least 20 fields. Continue counting until either 100 fibers are counted or 100 fields have been viewed; whichever occurs first. Count all the fibers in the final field.

(8) Fibers lying entirely within the boundary of the Walton-Beckett graticule field shall receive a count of 1. Fibers crossing the boundary once, having one end within the circle shall receive a count of 1/2. Do not count any fiber that crosses the graticule boundary more than once. Reject and do not count any other fibers even though they may be visible outside the graticule area. If a fiber touches the circle, it is considered to cross the line.

(9) Count bundles of fibers as one fiber unless individual fibers can be clearly identified and each individual fiber is clearly not connected to another counted fiber. See Figure 1 for counting conventions.

(10) Record the number of fibers in each field in a consistent way such that filter non-uniformity can be assessed.

(11) Regularly check phase ring alignment.

(12) When an agglomerate (mass of material) covers more than 25% of the field of view, reject the field and select another. Do not include it in the number of fields counted.

(13) Perform a "blind recount" of 1 in every 10 filter wedges (slides). Re-label the slides using a person other than the original counter.

6.7. Fiber Identification

As previously mentioned in Section 1.3., PCM does not provide positive confirmation of asbestos fibers. Alternate differential counting techniques should be used if discrimination is desirable. Differential counting may include primary discrimination based on morphology, polarized light analysis of fibers, or modification of PCM data by Scanning Electron or Transmission Electron Microscopy.

A great deal of experience is required to routinely and correctly perform differential counting. It is discouraged unless it is legally necessary. Then, only if a fiber is obviously not asbestos should it be excluded from the count. Further discussion of this technique can be found in reference 8.10.

If there is a question whether a fiber is asbestos or not, follow the rule:

"WHEN IN DOUBT, COUNT."

6.8. Analytical Recommendations—Quality Control System

6.8.1. All individuals performing asbestos analysis must have taken the NIOSH course for sampling and evaluating airborne asbestos or an equivalent course.

6.8.2. Each laboratory engaged in asbestos counting shall set up a slide trading arrangement with at least two other laboratories in order to compare performance and eliminate inbreeding of error. The slide exchange occurs at least semiannually. The round robin results shall be posted where all analysts can view individual analyst's results.

6.8.3. Each laboratory engaged in asbestos counting shall participate in the Proficiency Analytical Testing Program, the Asbestos Analyst Registry or equivalent.

6.8.4. Each analyst shall select and count prepared slides from a "slide bank". These are quality assurance counts. The slide bank shall be prepared using uniformly distributed samples taken from the workload. Fiber densities should cover the entire range routinely analyzed by the laboratory. These slides are counted blind by all counters to establish an original standard deviation. This historical distribution is com-pared with the quality assurance counts. A counter must have 95% of all quality control samples counted within three standard deviations of the historical mean. This count is then integrated into a new historical mean and standard deviation for the slide.

The analyses done by the counters to establish the slide bank may be used for an interim quality control program if the data are treated in a proper statistical fashion.

7. Calculations

7.1. Calculate the estimated airborne asbestos fiber concentration on the filter sample using the following formula:

$$AC = \frac{\left[\left(\frac{FB}{FL}\right) - \left(\frac{BFB}{BFL}\right)\right] \text{ x } ECA}{1000 \text{ x } FR \text{ x } MFA}$$

where:

AC = Airborne fiber concentration
FB = Total number of fibers greater than 5 µm counted
FL = Total number of fields counted on the filter
BFB = Total number of fibers greater than 5 µm counted in the blank
BFL = Total number of fields counted on the blank
ECA = Effective collecting area of filter (385 mm^2 nominal for a 25-mm filter.)
FR = Pump flow rate (L/min)
MFA = Microscope count field area (mm(2)). This is 0.00785 mm(2) for a Walton-Beckett Graticule.
T = Sample collection time (min)
1,000 = Conversion of L to cc

Note: The collection area of a filter is seldom equal to 385 mm(2). It is appropriate for laboratories to routinely monitor the exact diameter
using an inside micrometer. The collection area is calculated according to
the formula:

Area = š(d/2)^2

7.2. Short-Cut Calculation

Since a given analyst always has the same interpupillary distance, the number of fields per filter for a particular analyst will remain constant for a given size filter. The field size for that analyst is constant (i.e. the analyst is using an assigned microscope and is not changing the reticle).

For example, if the exposed area of the filter is always 385 mm(2) and the size of the field is always 0.00785 mm(2) the number of fields per filter will always be 49,000. In addition it is necessary to convert liters of air to cc. These three constants can then be combined such that ECA/(1,000 x MFA) = 49.

The previous equation simplifies to:

$$AC = \frac{\left(\frac{FB}{FL}\right) - \left(\frac{BFB}{BFL}\right) \text{ x } 49}{FR \text{ x } T}$$

7.3. Recount Calculations

As mentioned in step 13 of Section 6.6.2., a "blind recount" of 10% of the slides is performed. In all cases, differences will be observed between the first and second counts of the same filter wedge. Most of these differences will be due to chance alone, that is, due to the random variability (precision) of the count method. Statistical recount criteria enables one to decide whether observed differences can be explained due to chance alone or are probably due to systematic differences between analysts, microscopes, or other biasing factors.

The following recount criterion is for a pair of counts that estimate AC in fibers/cc. The criterion is given at the type-I error level. That is, there is 5% maximum risk that we will reject a pair of counts for the reason that one might be biased, when the large observed difference is really due to chance.

Reject a pair of counts if:

REGULATIONS

$$\left|\sqrt{AC_2} - \sqrt{AC_1}\right| > 2.78 \text{ x } \left(\sqrt{AC_{avg}}\right) \text{ x } CV_{FB}$$

Where:

AC_1 = lower estimated airborne fiber concentration
AC_2 = higher estimated airborne fiber concentration
AC_{avg} = average of the two concentration estimates
CV_{FB} = CV for the average of the two concentration estimates

If a pair of counts are rejected by this criterion then, recount the rest of the filters in the submitted set. Apply the test and reject any other pairs failing the test. Rejection shall include a memo to the industrial hygienist stating that the sample failed a statistical test for homogeneity and the true air concentration may be significantly different than the reported value.

7.4. Reporting Results

Report results to the industrial hygienist as fibers/cc. Use two significant figures. If multiple analyses are performed on a sample, an average of the results is to be reported unless any of the results can be rejected for cause.

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Quality Control

The OSHA asbestos regulations require each laboratory to establish a quality control program. The following is presented as an example of how the OSHA-SLTC constructed its internal CV curve as part of meeting this requirement. Data is from 395 samples collected during OSHA compliance inspections and analyzed from October 1980 through April 1986.

Each sample was counted by 2 to 5 different counters independently of one another. The standard deviation and the CV statistic was calculated for each sample. This data was then plotted on a graph of CV vs. fibers/mm(2). A least squares regression was performed using the following equation:

$$CV = \text{antilog}_{10}[A(\log_{10}(x))_2 + B(\log_{10}(x))+C]$$

Where:
x = the number of fibers/mm^2

Application of least squares gave:

A = 0.182205
B = 0.973343
C = 0.327499

R
E
G
U
L
A
T
I
O
N
S

Using these values, the equation becomes:

CV = antilog$_{10}$ [0.182205(log10(x))^2 - 0.973343(log$_{10}$ (x)) + 0.327499]

Sampling Pump Flow Rate Corrections

This correction is used if a difference greater than 5% in ambient temperature and/or pressure is noted between calibration and sampling sites and the pump does not compensate for the differences.

$$Q_{act} = Q_{cal} \times \sqrt{\left(\frac{P_{cal}}{P_{act}}\right) \times \left(\frac{T_{act}}{T_{cal}}\right)}$$

Where:

Q_{act} =	actual flow rate
Q_{cal} =	calibrated flow rate (if a rotameter was used, the rotameter value)
P_{cal} =	uncorrected air pressure at calibration
P_{act} =	uncorrected air pressure at sampling site
T_{act} =	temperature at sampling site (K)
T_{cal} =	temperature at calibration (K)

Walton-Beckett Graticule

When ordering the Graticule for asbestos counting, specify the exact disc diameter needed to fit the ocular of the microscope and the diameter (mm) of the circular counting area. Instructions for measuring the dimensions necessary are listed:

(1) Insert any available graticule into the focusing eyepiece and focus so that the graticule lines are sharp and clear.

(2) Align the microscope.

(3) Place a stage micrometer on the microscope object stage and focus the microscope on the graduated lines.

(4) Measure the magnified grid length, PL (um), using the stage micrometer.

(5) Remove the graticule from the microscope and measure its actual grid length, AL (mm). This can be accomplished by using a mechanical stage fitted with verniers, or a jeweler's loupe with a direct reading scale.

(6) Let D = 100 um. Calculate the circle diameter, d(c)(mm), for the Walton-Beckett graticule and specify the diameter when making a purchase:

$$d_c = \frac{AL \times D}{PL}$$

Example:

If PL = 108 um, AL = 2.93 mm and D = 100 µm, then,

$$d_c = \frac{2.93 \times 100}{108} = 2.71mm$$

(7) Each eyepiece-objective-reticle combination on the microscope must be calibrated. Should any of the three be changed (by zoom adjustment, disassembly, replacement, etc.), the combination must be recalibrated. Calibration may change if interpupillary distance is changed.

Measure the field diameter, D (acceptable range: 100 plus or minus 2 um) with a stage micrometer upon receipt of the graticule from the manufacturer. Determine the field area (mm^2).

Field Area = š (D ÷ 2)^2
If D = 100 µm = 0.1 mm, then
Field Area = š (0.1 mm ÷ 2)^2 = 0.00785 mm^2

The Graticule is available from: Graticules Ltd., Morley Road, Tonbridge TN9 IRN, Kent, England (Telephone 011-44-732-359061).
Also available from PTR Optics Ltd., 145 Newton Street, Waltham, MA 02154 [telephone (617) 891-6000] or McCrone Accessories and Components, 2506 S. Michigan Ave., Chicago, IL 60616 [phone (312)-842-7100]. The graticule is custom made for each microscope.
[60 FR 33972, June 29, 1995]

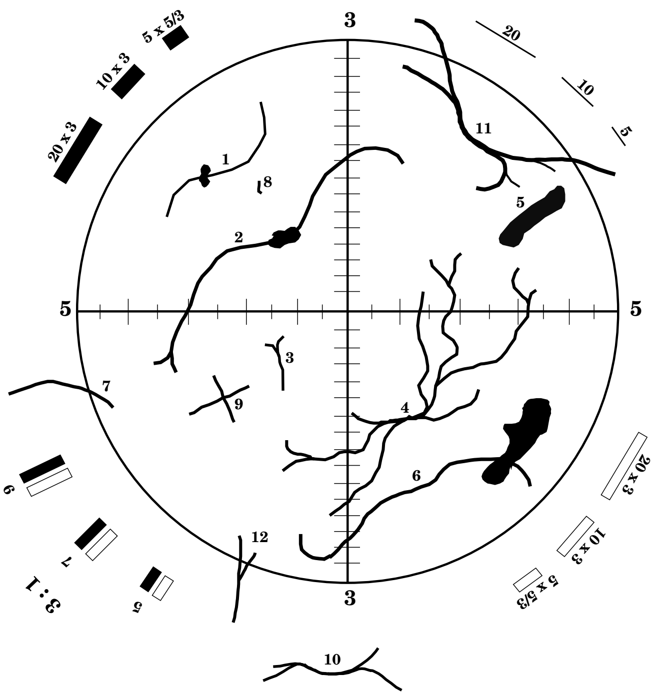

Figure 1: Walton-Beckett Graticule with some explanatory fibers

Structure No.	Count	Explanation
1 to 6	1	Single fibers all contained within the circle.
7	1/2	Fiber crosses circle once
8	0	Fiber too short
9	2	Two crossing fibers
10	0	Fiber outside graticule
11	0	Fiber crosses graticule twice
12	1/2	Although split, fiber only crosses once

Appendix C to 29 CFR 1926.1101
Qualitative and Quantitative Fit Testing Procedures - Mandatory

[Reserved]
[63 FR 1152, Jan. 8, 1998]

Appendix D to 29 CFR 1926.1101
Medical Questionnaires - Mandatory

This mandatory appendix contains the medical questionnaires that must be administered to all employees who are exposed to asbestos above the permissible exposure limit, and who will therefore be included in their employer's medical surveillance program. Part 1 of the appendix contains the Initial Medical Questionnaire, which must be obtained for all new hires who will be covered by the medical surveillance requirements. Part 2 includes the abbreviated Periodical Medical Questionnaire, which must be administered to all employees who are provided periodic medical examinations under the medical surveillance provisions of the standard.

Part 1
INITIAL MEDICAL QUESTIONNAIRE

1. NAME ____
2. SOCIAL SECURITY NUMBER # __________________________________
3. CLOCK NUMBER ____
4. PRESENT OCCUPATION ______________________________________
5. PLANT ____
6. ADDRESS ____
7. ____ (Zip Code)
8. TELEPHONE NUMBER _______________________________________
9. INTERVIEWER ____
10. DATE ____
11. Date of Birth ____
Month Day Year
12. Place of Birth ____
13. Sex 1. Male ___ 2. Female ___
14. What is your marital status? 1. Single ___ 2. Married ___ 3. Widowed ___ 4. Separated/Divorced ___
15. Race 1. White ___ 2. Black ___ 3. Asian ___ 4. Hispanic ___ 5. Indian ___ 6. Other ___
16. What is the highest grade completed in school? ___________ (For example 12 years is completion of high school)

OCCUPATIONAL HISTORY

17A. Have you ever worked full time (30 hours per week or more) for 6 months or more? 1. Yes ___ 2. No ___

IF YES TO 17A:

B. Have you ever worked for a year or more in any dusty job? 1. Yes ___ 2. No ___ 3. Does Not Apply ___

Specify job/industry ___________ Total Years Worked ________

Was dust exposure:
1. Mild ____ 2. Moderate ____ 3. Severe ____

C. Have you ever been exposed to gas or chemical fumes in your work? 1. Yes ___ 2. No ___
Specify job/industry _________________ Total Years Worked ___

Was exposure :
1. Mild ____ 2. Moderate ____ 3. Severe ____

D. What has been your usual occupation or job—the one you have worked at the longest?

1. Job occupation ____

R E G U L A T I O N S

2. Number of years employed in this occupation ______________

3. Position/job title ______________________________________

4. Business, field or industry _____________________________

(Record on lines the years in which you have worked in any of these industries, e.g. 1960-1969)

Have you ever worked:	YES	NO
E. In a mine?	_____	_____
F. In a quarry?	_____	_____
G. In a foundry?	_____	_____
H. In a pottery?	_____	_____
I. In a cotton, flax or hemp mill?	_____	_____
J. With asbestos?	_____	_____

18. PAST MEDICAL HISTORY

	YES	NO
A. Do you consider yourself to be in good health?	_____	_____
If "NO" state reason ___________________________________		
B. Have you any defect of vision?	_____	_____
If "YES" state nature of defect _________________________		
C. Have you any hearing defect?	_____	_____
If "YES" state nature of defect _________________________		
D. Are you suffering from or have you ever suffered from:		
a. Epilepsy (or fits, seizures, convulsions)?	_____	_____
b. Rheumatic fever?	_____	_____
c. Kidney disease?	_____	_____
d. Bladder disease?	_____	_____
e. Diabetes?	_____	_____
f. Jaundice?	_____	_____

19. CHEST COLDS AND CHEST ILLNESSES

19A. If you get a cold, does it "usually" go to your chest? (Usually means more than 1/2 the time)
1. Yes ___ 2. No ___ 3. Don't get colds ___

20A. During the past 3 years, have you had any chest illnesses that have kept you off work, indoors at home, or in bed?
1. Yes ___ 2. No ___

REGULATIONS

IF YES TO 20A:

B. Did you produce phlegm with any of these chest illnesses?
1. Yes ___ 2. No ___ 3. Does Not Apply ___

C. In the last 3 years, how many such illnesses with (increased) phlegm did you have which lasted a week or more?

Number of illnesses ___ No such illnesses ___

21. Did you have any lung trouble before the age of 16? 1. Yes ___ 2. No ___

22. Have you ever had any of the following?

1A. Attacks of bronchitis 1. Yes ___ 2. No ___

IF YES TO 1A:

B. Was it confirmed by a doctor? 1. Yes ___ 2. No ___ 3. Does Not Apply ___

C. At what age was your first attack? Age in Years ___ Does Not Apply ___

2A. Pneumonia (include bronchopneumonia)? 1. Yes ___ 2. No ___

IF YES TO 2A:

B. Was it confirmed by a doctor? 1. Yes ___ 2. No ___ 3. Does Not Apply ___

C. At what age did you first have it? Age in Years ___ Does Not Apply ___

3A. Hay Fever? 1. Yes ___ 2. No ___

IF YES TO 3A:

B. Was it confirmed by a doctor? 1. Yes ___ 2. No ___ 3. Does Not Apply ___

C. At what age did it start? Age in Years ___ Does Not Apply ___

23A. Have you ever had chronic bronchitis? 1. Yes ___ 2. No ___

IF YES TO 23A:

B. Do you still have it? 1. Yes ___ 2. No ___ 3. Does Not Apply ___

C. Was it confirmed by a doctor? 1. Yes ___ 2. No ___ 3. Does Not Apply ___

D. At what age did it start? Age in Years ___ Does Not Apply ___

24A. Have you ever had emphysema? 1. Yes ___ 2. No ___

IF YES TO 24A:
B. Do you still have it? 1. Yes ___ 2. No ___ 3. Does Not Apply ___

C. Was it confirmed by a doctor? 1. Yes ___ 2. No ___ 3. Does Not Apply ___

D. At what age did it start? Age in Years ___ Does Not Apply ___

25A. Have you ever had asthma? 1. Yes ___ 2. No ___

IF YES TO 25A:

B. Do you still have it? 1. Yes ___ 2. No ___ 3. Does Not Apply ___

C. Was it confirmed by a doctor? 1. Yes ___ 2. No ___ 3. Does Not Apply ___

D. At what age did it start? Age in Years ___ Does Not Apply ___

E. If you no longer have it, at what age did it stop? Age stopped ___ Does Not Apply ___

26. Have you ever had:

A. Any other chest illness? 1. Yes ___ 2. No ___

If yes, please specify ___________________________________

B. Any chest operations? 1. Yes ___ 2. No ___

If yes, please specify ___________________________________

C. Any chest injuries? 1. Yes ___ 2. No ___

If yes, please specify ___________________________________

27A. Has a doctor ever told you that you had heart trouble? 1. Yes ___ 2. No ___

IF YES TO 27A:

B. Have you ever had treatment for heart trouble in the past 10 years? 1. Yes ___ 2. No ___ 3. Does Not Apply ___

28A. Has a doctor told you that you had high blood pressure? 1. Yes ___ 2. No ___

IF YES TO 28A:

B. Have you had any treatment for high blood pressure (hypertension) in the past 10 years? 1. Yes ___ 2. No ___ 3. Does Not Apply ___

29. When did you last have your chest X-rayed?
(Year) ___ ___ ___ ___

30. Where did you last have your chest X-rayed (if known)? ___________________________________

What was the outcome? ___________________________________

REGULATIONS

FAMILY HISTORY

31. Were either of your natural parents ever told by a doctor that they had a chronic lung condition such as:

	FATHER			MOTHER		
	1. Yes	2. No	3. Don't know	1. Yes	2. No	3. Don't know
A. Chronic Bronchitis?	___	___	___	___	___	___
B. Emphysema?	___	___	___	___	___	___
C. Asthma?	___	___	___	___	___	___
D. Lung cancer?	___	___	___	___	___	___
E. Other chest conditions?	___	___	___	___	___	___
F. Is parent currently alive?	___	___	___	___	___	___

G. Please Specify

FATHER	MOTHER
___ Age if Living	___ Age if Living
___ Age at Death	___ Age at Death
___ Don't Know	___ Don't Know

H. Please specify cause of death: ____________________ ____________________

COUGH

32A. Do you usually have a cough? (Count a cough with first smoke or on first going out of doors. Exclude clearing of throat.) 1. Yes ___ 2. No ___
(If no, skip to question 32C.)

B. Do you usually cough as much as 4 to 6 times a day 4 or more days out of the week? 1. Yes ___ 2. No ___

C. Do you usually cough at all on getting up or first thing in the morning? 1. Yes ___ 2. No ___

D. Do you usually cough at all during the rest of the day or at night? 1. Yes ___ 2. No ___

IF YES TO ANY OF ABOVE (32A, B, C, OR D,), ANSWER THE FOLLOWING.
IF NO TO ALL, CHECK "DOES NOT APPLY" AND SKIP TO NEXT PAGE

E. Do you usually cough like this on most days for 3 consecutive months or more during the year? 1. Yes ___ 2. No ___ 3. Does not apply ___

F. For how many years have you had the cough? Number of years ___ Does not apply ___

33A. Do you usually bring up phlegm from your chest? (Count phlegm with the first smoke or on first going out of doors. Exclude phlegm from the nose. Count swallowed phlegm.) 1. Yes ___ 2. No ___
(If no, skip to 33C)

B. Do you usually bring up phlegm like this as much as twice a day 4 or more days out of the week? 1. Yes ___ 2. No ___

C. Do you usually bring up phlegm at all on getting up or first thing in the morning? 1. Yes ___ 2. No ___

D. Do you usually bring up phlegm at all on during the rest of the day or at night? 1. Yes ___ 2. No ___

IF YES TO ANY OF THE ABOVE (33A, B, C, OR D), ANSWER THE FOLLOWING:

IF NO TO ALL, CHECK "DOES NOT APPLY" AND SKIP TO 34A

E. Do you bring up phlegm like this on most days for 3 consecutive months or more during the year? 1. Yes ___ 2. No ___ 3. Does not apply ___

F. For how many years have you had trouble with phlegm? Number of years ___ Does not apply ___

EPISODES OF COUGH AND PHLEGM

34A. Have you had periods or episodes of (increased*) cough and phlegm lasting for 3 weeks or more each year? 1. Yes ___ 2. No ___
* (For persons who usually have cough and/or phlegm)

IF YES TO 34A

B. For how long have you had at least 1 such episode per year? Number of years ___ Does not apply ___

WHEEZING

35A. Does your chest ever sound wheezy or whistling

1. When you have a cold? 1. Yes ___ 2. No ___

2. Occasionally apart from colds? 1. Yes ___ 2. No ___

3. Most days or nights? 1. Yes ___ 2. No ___

IF YES TO 1, 2, or 3 in 35A

B. For how many years has this been present? Number of years ___ Does not apply ___

36A. Have you ever had an attack of wheezing that has made you feel short of breath? 1. Yes ___ 2. No ___

IF YES TO 36A

B. How old were you when you had your first such attack? Number of years ___ Does not apply ___

C. Have you had 2 or more such episodes? 1. Yes ___ 2. No ___ 3. Does not apply ___

D. Have you ever required medicine or treatment for the(se) attack(s)? 1. Yes ___ 2. No ___ 3. Does not apply ___

BREATHLESSNESS

37. If disabled from walking by any condition other than heart or lung disease, please describe and proceed to question 39A.

Nature of condition(s) ____

REGULATIONS

38A. Are you troubled by shortness of breath when hurrying on the level or walking up a slight hill? 1. Yes ___ 2. No ___

IF YES TO 38A

B. Do you have to walk slower than people of your age on the level because of breathlessness? 1. Yes ___ 2. No ___ 3. Does not apply ___

C. Do you ever have to stop for breath when walking at your own pace on the level? 1. Yes ___ 2. No ___ 3. Does not apply ___

D. Do you ever have to stop for breath after walking about 100 yards (or after a few minutes) on the level? 1. Yes ___ 2. No ___ 3. Does not apply ___

E. Are you too breathless to leave the house or breathless on dressing or climbing one flight of stairs? 1. Yes ___ 2. No ___ 3. Does not apply ___

TOBACCO SMOKING

39A. Have you ever smoked cigarettes? (No means less than 20 packs of cigarettes or 12 oz. of tobacco in a lifetime or less than 1 cigarette a day for 1 year.) 1. Yes ___ 2. No ___

IF YES TO 39A

B. Do you now smoke cigarettes (as of one month ago) 1. Yes ___ 2. No ___ 3. Does not apply ___

C. How old were you when you first started regular cigarette smoking? Age in years ___ Does not apply ___

D. If you have stopped smoking cigarettes completely, how old were you when you stopped? Age stopped ___ Check if still smoking ___ Does not apply ___

E. How many cigarettes do you smoke per day now? Cigarettes per day ___ Does not apply ___

F. On the average of the entire time you smoked, how many cigarettes did you smoke per day? Cigarettes per day ___ Does not apply ___

G. Do or did you inhale the cigarette smoke?

1. Does not apply ___
2. Not at all ___
3. Slightly ___
4. Moderately ___
5. Deeply ___

40A. Have you ever smoked a pipe regularly? 1. Yes ___ 2. No ___ 3. Does not apply ___
(Yes means more than 12 oz. of tobacco in a lifetime.)

IF YES TO 40A:
FOR PERSONS WHO HAVE EVER SMOKED A PIPE

B. 1. How old were you when you started to smoke a pipe regularly? Age ___

2. If you have stopped smoking a pipe completely, how old were you when you stopped?
Age stopped ___
Check if still smoking pipe ___
Does not apply ___

C. On the average over the entire time you smoked a pipe, how much pipe tobacco did you smoke per week?
___ oz. per week (a standard pouch of tobacco contains 1 1/2 oz.) ___ Does not apply

D. How much pipe tobacco are you smoking now? ___ oz. per week Not currently smoking a pipe ___

E. Do you or did you inhale the pipe smoke?
1. Never smoked ___
2. Not at all ___
3. Slightly ___
4. Moderately ___
5. Deeply ___

41A. Have you ever smoked cigars regularly? 1. Yes ___ 2. No ___
(Yes means more than 1 cigar a week for a year)

IF YES TO 41A

FOR PERSONS WHO HAVE EVER SMOKED A CIGARS

B. 1. How old were you when you started smoking cigars regularly? Age ___

2. If you have stopped smoking cigars completely, how old were you when you stopped.
Age stopped ___ Check if still smoking cigars ___ Does not apply ___

C. On the average over the entire time you smoked cigars, how many cigars did you smoke per week?
Cigars per week ___ Does not apply ___

D. How many cigars are you smoking per week now?
Cigars per week ___ Check if not smoking cigars currently ___

E. Do or did you inhale the cigar smoke?
1. Never smoked ___
2. Not at all ___
3. Slightly ___
4. Moderately ___
5. Deeply ___

Signature ____________________________ Date _____________________

PART 2
PERIODIC MEDICAL QUESTIONNAIRE

1. NAME ____

2. SOCIAL SECURITY NUMBER # ______________________________

3. CLOCK NUMBER ______________________________________

4. PRESENT OCCUPATION ________________________________

5. PLANT ____

6. ADDRESS ____

7. ____ (Zip Code)

8. TELEPHONE NUMBER __________________________________

9. INTERVIEWER ______________________________________

10. DATE ____

11. What is your marital status? 1. Single ___ 2. Married ___ 3. Widowed ___ 4. Separated/Divorced ___

12. OCCUPATIONAL HISTORY

12A. In the past year, did you work full time (30 hours per week or more) for 6 months or more? 1. Yes ___ 2. No ___

IF YES TO 12A:

12B. In the past year, did you work in a dusty job? 1. Yes ___ 2. No ___ 3. Does not Apply ___

12C. Was dust exposure: 1. Mild ___ 2. Moderate ___ 3. Severe ___

12D. In the past year, were you exposed to gas or chemical fumes in your work? 1. Yes ___ 2. No ___

12E. Was exposure: 1. Mild ___ 2. Moderate ___ 3. Severe ___

12F. In the past year, what was your: 1. Job/occupation? ______________________
2. Position/job title? ______________________

13. RECENT MEDICAL HISTORY

13A. Do you consider yourself to be in good health? Yes ___ No ___
If NO, state reason ______________________________

13B. In the past year, have you developed:

	Yes	No
Epilepsy?	___	___
Rheumatic fever?	___	___
Kidney disease?	___	___
Bladder disease?	___	___
Diabetes?	___	___
Jaundice?	___	___
Cancer?	___	___

REGULATIONS

14. CHEST COLDS AND CHEST ILLNESSES

14A. If you get a cold, does it "usually" go to your chest? (usually means more than 1/2 the time)
1. Yes ___ 2. No ___ 3. Don't get colds ___

15A. During the past year, have you had any chest illnesses that have kept you off work, indoors at home, or in bed? 1. Yes ___ 2. No ___ 3. Does Not Apply ___
IF YES TO 15A:

15B. Did you produce phlegm with any of these chest illnesses? 1. Yes ___ 2. No ___3. Does Not Apply ___

15C. In the past year, how many such illnesses with (increased) phlegm did you have which lasted a week or more?
Number of illnesses ___ No such illnesses ___

16. RESPIRATORY SYSTEM

In the past year have you had:

	Yes or No	Further Comment on Positive Answers
Asthma	_____	
Bronchitis	_____	
Hay Fever	_____	
Other Allergies	_____	

	Yes or No	Further Comment on Positive Answers
Pneumonia	_____	
Tuberculosis	_____	
Chest Surgery	_____	
Other Lung Problems	_____	
Heart Disease	_____	

Do you have:

	Yes or No	Further Comment on Positive Answers
Frequent colds	_____	
Chronic cough	_____	
Shortness of breath when walking or climbing one flight or stairs	_____	

Do you:

Wheeze	_____		
Cough up phlegm	_____		
Smoke cigarettes	_____	Packs per day ____	How many years ___

Date __________________ Signature _______________________________

[59 FR 40964, Aug. 10, 1994

Appendix E to 29 CFR 1926.1101
Interpretation and Classification of Chest Roentgenograms - Mandatory

(a) Chest roentgenograms shall be interpreted and classified in accordance with a professionally accepted classification system and recorded on an interpretation form following the format of the CDC/NIOSH (M) 2.8 form. As a minimum, the content within the bold lines of this form (items 1 through 4) shall be included. This form is not to be submitted to NIOSH..

(b) Roentgenograms shall be interpreted and classified only by a B-reader, a board eligible/certified radiologist, or an experienced physician with known expertise in pneumoconioses.

(c) All interpreters, whenever interpreting chest roentgenograms made under this section, shall have immediately available for reference a complete set of the ILO-U/C International Classification of Radiographs for Pneumoconioses, 1980.

Appendix F to 29 CFR 1926.1101
Work Practices and Engineering Controls for Class I Asbestos Operations - Non-Mandatory

This is a non-mandatory appendix to the asbestos standards for construction and for shipyards. It describes criteria and procedures for erecting and using negative pressure enclosures for Class I Asbestos Work, when NPEs are used as an allowable control method to comply with paragraph (g)(5)(i) of this section. Many small and variable details are involved in the erection of a negative pressure enclosure. OSHA and most participants in the rulemaking agreed that only the major, more performance oriented criteria should be made mandatory. These criteria are set out in paragraph (g) of this section. In addition, this appendix includes these mandatory specifications and procedures in its guidelines in order to make this appendix coherent and helpful. The mandatory nature of the criteria which appear in the regulatory text is not changed because they are included in this “non-mandatory” appendix. Similarly, the additional criteria and procedures included as guidelines in the appendix, do not become mandatory because mandatory criteria are also included in these comprehensive guidelines.

In addition, none of the criteria, both mandatory and recommended, are meant to specify or imply the need for use of patented or licensed methods or equipment. Recommended specifications included in this attachment should not discourage the use of creative alternatives which can be shown to reliably achieve the objectives of negative-pressure enclosures.

Requirements included in this appendix, cover general provisions to be followed in all asbestos jobs, provisions which must be followed for all Class I asbestos jobs, and provisions governing the construction and testing of negative pressure enclosures. The first category includes the requirement for use of wet methods, HEPA vacuums, and immediate bagging of waste; Class I work must conform to the following provisions:

- oversight by competent person
- use of critical barriers over all openings to work area
- isolation of HVAC systems
- use of impermeable dropcloths and coverage of all objects within regulated areas

In addition, more specific requirements for NPEs include:

- maintenance of -0.02 inches water gauge within enclosure
- manometric measurements
- air movement away from employees performing removal work
- smoke testing or equivalent for detection of leaks and air direction
- deactivation of electrical circuits, if not provided with ground-fault circuit interrupters.

Planning the Project

The standard requires that an exposure assessment be conducted before the asbestos job is begun [Sec. 1926.1101 (f)(1)]. Information needed for that assessment, includes data relating to prior similar jobs, as applied to the specific variables of the current job. The information needed to conduct the assessment will be useful in planning the project, and in complying with any reporting requirements under this standard, when significant changes are being made to a control system listed in the standard, [see also those of USEPA (40 CFR 61, subpart M). Thus, although the standard does not explicitly require the preparation of a written asbestos removal plan, the usual constituents of such a plan, i.e., a description of the enclosure, the equipment, and the procedures to be used throughout the project, must be determined before the enclosure can be erected. The following information should be included in the planning of the system:

A physical description of the work area;

A description of the approximate amount of material to be removed;

A schedule for turning off and sealing existing ventilation systems;

Personnel hygiene 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 and how they are to be tested;

A description of work practices to be observed by employees;

An air monitoring plan;

A description of the method to be used to transport waste material; and

The location of the dump site.

Materials and Equipment Necessary for Asbestos Removal

Although individual asbestos removal projects vary in terms of the equipment required to accomplish the removal of the materials, some equipment and materials are common to most asbestos removal operations.

Plastic sheeting used to protect horizontal surfaces, seal HVAC openings or to seal vertical openings and ceilings should have a minimum thickness of 6 mils. Tape or other adhesive used to attach plastic sheeting should be of sufficient adhesive strength to support the weight of the material plus all stresses encountered during the entire duration of the project without becoming detached from the surface.

Other equipment and materials which should be available at the beginning of each project are:

– HEPA Filtered Vacuum is essential for cleaning the work area after the asbestos has been removed. It should have a long hose capable of reaching out-of-the-way places, such as areas above ceiling tiles, behind pipes, etc.

– Portable air ventilation systems installed to provide the negative air pressure and air removal from the enclosure must be equipped with a HEPA filter. The number and capacity of units required to ventilate an closure depend on the size of the area to be ventilated. The filters for these systems should be designed in such a manner that they can be replaced when the air flow volume is reduced by the build-up of dust in the filtration material. Pressure monitoring devices with alarms and strip chart recorders attached to each system to indicate the pressure differential and the loss due to dust buildup on the filter are recommended.

– Water sprayers should be used to keep the asbestos material as saturated as possible during removal; the sprayers will provide a fine mist that minimizes the impact of the spray on the material.

– Water used to saturate the asbestos containing material can be amended by adding at least 15 milliliters (1/4 ounce) of wetting agent in 1 liter (1 pint) of water. An example of a wetting agent is a 50/50 mixture of polyoxyethylene ether and polyoxyethylene polyglycol ester.

– Backup power supplies are recommended, especially for ventilation systems.

– Shower and bath water should be with mixed hot and cold water faucets. Water that has been used to clean personnel or equipment should either be filtered or be collected and discarded as asbestos waste. Soap and shampoo should be provided to aid in removing dust from the workers' skin and hair.

– See paragraphs (h) and (i) of this section for appropriate respiratory protection and protective clothing.

– See paragraph (k) of this section for required signs and labels.

REGULATIONS

Preparing the Work Area

Disabling HVAC Systems: The power to the heating, ventilation, and air conditioning systems that service the restricted area must be deactivated and locked off. All ducts, grills, access ports, windows and vents must be sealed off with two layers of plastic to prevent entrainment of contaminated air.

Operating HVAC Systems in the Restricted Area: If components of a HVAC system located in the restricted area are connected to a system that will service another zone during the project, the portion of the duct in the restricted area must be sealed and pressurized. Necessary precautions include caulking the duct joints, covering all cracks and openings with two layers of sheeting, and pressurizing the duct throughout the duration of the project by restricting the return air flow. The power to the fan supplying the positive pressure should be locked "on" to prevent pressure loss.

Sealing Elevators: If an elevator shaft is located in the restricted area, it should be either shut down or isolated by sealing with two layers of plastic sheeting. The sheeting should provide enough slack to accommodate the pressure changes in the shaft without breaking the air-tight seal.

Removing Mobile Objects: All movable objects should be cleaned and removed from the work area before an enclosure is constructed unless moving the objects creates a hazard. Mobile objects will be assumed to be contaminated and should be either cleaned with amended water and a HEPA vacuum and then removed from the area or wrapped and then disposed of as hazardous waste.

Cleaning and Sealing Surfaces: After cleaning with water and a HEPA vacuum, surfaces of stationary objects should be covered with two layers of plastic sheeting. The sheeting should be secured with duct tape or an equivalent method to provide a tight seal around the object.

Bagging Waste: In addition to the requirement for immediate bagging of waste for disposal, it is further recommended that the waste material be double-bagged and sealed in plastic bags designed for asbestos disposal. The bags should be stored in a waste storage area that can be controlled by the workers conducting the removal. Filters removed from air handling units and rubbish removed from the area are to be bagged and handled as hazardous waste.

Constructing the Enclosure

The enclosure should be constructed to provide an air-tight seal around ducts and openings into existing ventilation systems and around penetrations for electrical conduits, telephone wires, water lines, drain pipes, etc. Enclosures should be both airtight and watertight except for those openings designed to provide entry and/or air flow control.

Size: An enclosure should be the minimum volume to encompass all of the working surfaces yet allow unencumbered movement by the worker(s), provide unrestricted air flow past the worker(s), and ensure walking surfaces can be kept free of tripping hazards.

Shape: The enclosure may be any shape that optimizes the flow of ventilation air past the worker(s).

Structural Integrity: The walls, ceilings and floors must be supported in such a manner that portions of the enclosure will not fall down during normal use.

Openings: It is not necessary that the structure be airtight; openings may be designed to direct air flow. Such openings should be located at a distance from active removal operations. They should be designed to draw air into the enclosure under all anticipated circumstances. In the event that negative pressure is lost, they should be fitted with either HEPA filters to trap dust or automatic trap doors that prevent dust from escaping the enclosure. Openings for exits should be controlled by an airlock or a vestibule.

Barrier Supports: Frames should be constructed to support all unsupported spans of sheeting.

Sheeting: Walls, barriers, ceilings, and floors should be lined with two layers of plastic sheeting having a thickness of at least 6 mil.

Seams: Seams in the sheeting material should be minimized to reduce the possibilities of accidental rips and tears in the adhesive or connections. All seams in the sheeting should overlap, be staggered and not be located at corners or wall-to-floor joints. Areas Within an Enclosure: Each enclosure consists of a work area, a decontamination area, and waste storage area. The work area where the asbestos removal operations occur should be separated from both the waste storage area and the contamination control area by physical curtains, doors, and/or airflow patterns that force any airborne contamination back into the work area.

See paragraph (j) of this section for requirements for hygiene facilities.

During egress from the work area, each worker should step into the equipment room, clean tools and equipment, and remove gross contamination from clothing by wet cleaning and HEPA vacuuming. Before entering the shower area, foot coverings, head coverings, hand coverings, and coveralls are removed and placed in impervious bags for disposal or cleaning. Airline connections from airline respirators with HEPA disconnects and power cables from powered air-purifying respirators (PAPRs) will be disconnected just prior to entering the shower room.

Establishing Negative Pressure Within the Enclosure

Negative Pressure: Air is to be drawn into the enclosure under all anticipated conditions and exhausted through a HEPA filter for 24 hours a day during the entire duration of the project.

Air Flow Tests: Air flow patterns will be checked before removal operations begin, at least once per operating shift and any time there is a question regarding the integrity of the enclosure. The primary test for air flow is to trace air currents with smoke tubes or other visual methods. Flow checks are made at each opening and at each doorway to demonstrate that air is being drawn into the enclosure and at each worker's position to show that air is being drawn away from the breathing zone.

Monitoring Pressure Within the Enclosure: After the initial air flow patterns have been checked, the static pressure must be monitored within the enclosure. Monitoring may be made using manometers, pressure gauges, or combinations of these devices. It is recommended that they be attached to alarms and strip chart recorders at points identified by the design engineer.

Corrective Actions: If the manometers or pressure gauges demonstrate a reduction in pressure differential below the required level, work should cease and the reason for the change investigated and appropriate changes made. The air flow patterns should be retested before work begins again.

Pressure Differential: The design parameters for static pressure differentials between the inside and outside of enclosures typically range from 0.02 to 0.10 inches of water gauge, depending on conditions. All zones inside the enclosure must have less pressure than the ambient pressure outside of the enclosure (-0.02 inches water gauge differential). Design specifications for the differential vary according to the size, configuration, and shape of the enclosure as well as ambient and mechanical air pressure conditions around the enclosure.

Air Flow Patterns: The flow of air past each worker shall be enhanced by positioning the intakes and exhaust ports to remove contaminated air from the worker's breathing zone, by positioning HEPA vacuum cleaners to draw air from the worker's breathing zone, by forcing relatively uncontaminated air past the worker toward an exhaust port, or by using a combination of methods to reduce the worker's exposure.

Air Handling Unit Exhaust: The exhaust plume from air handling units should be located away from adjacent personnel and intakes for HVAC systems.

Air Flow Volume: The air flow volume (cubic meters per minute) exhausted (removed) from the workplace must exceed the amount of makeup air supplied to the enclosure. The rate of air exhausted from the enclosure should be designed to maintain a negative pressure in the enclosure and air movement past each worker. The volume of air flow removed from the enclosure should replace the volume of the container at every 5 to 15 minutes. Air flow volume will need to be relatively high for large enclosures, enclosures with awkward shapes, enclosures with multiple openings, and operations employing several workers in the enclosure.

Air Flow Velocity: At each opening, the air flow velocity must visibly "drag" air into the enclosure. The velocity of air flow within the enclosure must be adequate to remove airborne contamination from each worker's breathing zone without disturbing the asbestos-containing material on surfaces.

Airlocks: Airlocks are mechanisms on doors and curtains that control the air flow patterns in the doorways. If air flow occurs, the patterns through doorways must be such that the air flows toward the inside of the enclosure. Sometimes vestibules, double doors, or double curtains are used to prevent air movement through the doorways. To use a vestibule, a worker enters a chamber by opening the door or curtain and then closing the entry before opening the exit door or curtain.

Airlocks should be located between the equipment room and shower room, between the shower room and the clean room, and between the waste storage area and the outside of the enclosure. The air flow between adjacent rooms must be checked using smoke tubes or other visual tests to ensure the flow patterns draw air toward the work area without producing eddies.

Monitoring for Airborne Concentrations

In addition to the breathing zone samples taken as outlined in paragraph (f) of this section, samples of air should be taken to demonstrate the integrity of the enclosure, the cleanliness of the clean room and shower area, and the effectiveness of the HEPA filter. If the clean room is shown to be contaminated, the room must be relocated to an uncontaminated area.

Samples taken near the exhaust of portable ventilation systems must be done with care.

General Work Practices

Preventing dust dispersion is the primary means of controlling the spread of asbestos within the enclosure. Whenever practical, the point of removal should be isolated, enclosed, covered, or shielded from the workers in the area. Waste asbestos containing materials must be bagged during or immediately after removal; the material must remain saturated until the waste container is sealed.

Waste material with sharp points or corners must be placed in hard air-tight containers rather than bags.

Whenever possible, large components should be sealed in plastic sheeting and removed intact.

Bags or containers of waste will be moved to the waste holding area, washed, and wrapped in a bag with the appropriate labels.

Cleaning the Work Area

Surfaces within the work area should be kept free of visible dust and debris to the extent feasible. Whenever visible dust appears on surfaces, the surfaces within the enclosure must be cleaned by wiping with a wet sponge, brush, or cloth and then vacuumed with a HEPA vacuum.

All surfaces within the enclosure should be cleaned before the exhaust ventilation system is deactivated and the enclosure is disassembled. An approved encapsulant may be sprayed onto areas after the visible dust has been removed.

[59 FR 40964, Aug. 10, 1994; 60 FR 33972, June 29, 1995]

Appendix G to 29 CFR 1926.1101
[Reserved]

Appendix G removed and reserved at 59 FR 41152, August 10, 1994, effective October 11, 1994.

Appendix H to 29 CFR 1926.1101 Substance Technical Information for Asbestos - Non-Mandatory

I. Substance Identification

A. Substance: “Asbestos” is the name of a class of magnesium-silicate minerals that occur in fibrous form. Minerals that are included in this group are chrysotile, crocidolite, amosite, anthophyllite asbestos, tremolite asbestos, and actinolite asbestos.

B. Asbestos is and was used in the manufacture of heat-resistant clothing, automotive brake and clutch linings, and a variety of building materials including floor tiles, roofing felts, ceiling tiles, asbestos-cement pipe and sheet, and fire-resistant drywall. Asbestos is also present in pipe and boiler insulation materials and in sprayed-on materials located on beams, in crawlspaces, and between walls.

C. The potential for an asbestos-containing product to release breathable fibers depends largely on its degree of friability. Friable means that the material can be crumbled with hand pressure and is therefore likely to emit fibers. The fibrous fluffy sprayed-on materials used for fireproofing, insulation, or sound proofing are considered to be friable, and they readily release airborne fibers if disturbed. Materials such as vinyl-asbestos floor tile or roofing felt are considered non-friable if intact and generally do not emit airborne fibers unless subjected to sanding, sawing and other aggressive operations. Asbestos-cement pipe or sheet can emit airborne fibers if the materials are cut or sawed, or if they are broken.

D. Permissible exposure: Exposure to airborne asbestos fibers may not exceed 0.1 fibers per cubic centimeter of air (0.1 f/cc) averaged over the 8-hour workday, and 1 fiber per cubic centimeter of air (1.0 f/cc) averaged over a 30 minute work period.

II. Health Hazard Data

A. Asbestos can cause disabling respiratory disease and various types of cancers if the fibers are inhaled. Inhaling or ingesting fibers from contaminated clothing or skin can also result in these diseases. The symptoms of these diseases generally do not appear for 20 or more years after initial exposure.

B. Exposure to asbestos has been shown to cause lung cancer, mesothelioma, and cancer of the stomach and colon. Mesothelioma is a rare cancer of the thin membrane lining of the chest and abdomen. Symptoms of mesothelioma include shortness of breath, pain in the walls of the chest, and/or abdominal pain.

III. Respirators and Protective Clothing

A. Respirators: You are required to wear a respirator when performing tasks that result in asbestos exposure that exceeds the permissible exposure limit (PEL) of 0.1 f/cc and when performing certain designated operations. Air-purifying respirators equipped with a high-efficiency particulate air (HEPA) filter can be used where airborne asbestos fiber concentrations do not exceed 1.0 f/cc; otherwise, more protective respirators such as air-supplied, positive-pressure, full facepiece respirators must be used. Disposable respirators or dust masks are not permitted to be used for asbestos work. For effective protection, respirators must fit your face and head snugly. Your employer is required to conduct a fit test when you are first assigned a respirator and every 6 months thereafter. Respirators should not be loosened or removed in work situations where their use is required.

B. Protective Clothing: You are required to wear protective clothing in work areas where asbestos fiber concentrations exceed the permissible exposure limit (PEL) of 0.1 f/cc.

IV. Disposal Procedures and Clean-up

A. Wastes that are generated by processes where asbestos is present include:

1. Empty asbestos shipping containers.
2. Process wastes such as cuttings, trimmings, or reject materials.
3. Housekeeping waste from wet-sweeping or HEPA-vacuuming.
4. Asbestos fireproofing or insulating material that is removed from buildings.
5. Asbestos-containing building products removed during building renovation or demolition.
6. Contaminated disposable protective clothing.

B. Empty shipping bags can be flattened under exhaust hoods and packed into airtight containers for disposal. Empty shipping drums are difficult to clean and should be sealed.

C. Vacuum bags or disposable paper filters should not be cleaned, but should be sprayed with a fine water mist and placed into a labeled waste container.

D. Process waste and housekeeping waste should be wetted with water or a mixture of water and surfactant prior to packaging in disposable containers.

E. Asbestos-containing material that is removed from buildings must be disposed of in leak-tight 6-mil plastic bags, plastic-lined cardboard containers, or plastic-lined metal containers. These wastes, which are removed while wet, should be sealed in containers before they dry out to minimize the release of asbestos fibers during handling.

V. Access to Information

A. Each year, your employer is required to inform you of the information contained in this standard and appendices for asbestos. In addition, your employer must instruct you in the proper work practices for handling asbestos-containing materials, and the correct use of protective equipment.

B. Your employer is required to determine whether you are being exposed to asbestos. Your employer must treat exposure to thermal system insulation and sprayed-on and troweled-on surfacing material as asbestos exposure, unless results of laboratory analysis show that the material does not contain asbestos. You or your representative has the right to observe employee measurements and to record the results obtained. Your employer is required to inform you of your exposure, and, if you are exposed above the permissible exposure limit, he or she is required to inform you of the actions that are being taken to reduce your exposure to within the permissible limit.

C. Your employer is required to keep records of your exposures and medical examinations. These exposure records must be kept for at least thirty (30) years. Medical records must be kept for the period of your employment plus thirty (30) years.

D. Your employer is required to release your exposure and medical records to your physician or designated representative upon your written request.

[59 FR 40964, Aug. 10, 1994; 60 FR 33972, June 29, 1995]

Appendix I to 29 CFR 1926.1101 Medical Surveillance Guidelines for Asbestos - Non-Mandatory

I. Route of Entry

Inhalation, ingestion.

II. Toxicology

Clinical evidence of the adverse effects associated with exposure to asbestos is present in the form of several well-conducted epidemiological studies of occupationally exposed workers, family contacts of workers, and persons living near asbestos mines. These studies have shown a definite association between exposure to asbestos and an increased incidence of lung cancer, pleural and peritoneal mesothelioma, gastrointestinal cancer, and asbestosis. The latter is a disabling fibrotic lung disease that is caused only by exposure to asbestos. Exposure to asbestos has also been associated with an increased incidence of esophageal, kidney, laryngeal, pharyngeal, and buccal cavity cancers. As with other known chronic occupational diseases, disease associated with asbestos generally appears about 20 years following the first occurrence of exposure: There are no known acute effects associated with exposure to asbestos.

Epidemiological studies indicate that the risk of lung cancer among exposed workers who smoke cigarettes is greatly increased over the risk of lung cancer among non-exposed smokers or exposed nonsmokers. These studies suggest that cessation of smoking will reduce the risk of lung cancer for a person exposed to asbestos, but will not reduce it to the same level of risk as that existing for an exposed worker who has never smoked.

III. Signs and Symptoms of Exposure-Related Disease

The signs and symptoms of lung cancer or gastrointestinal cancer induced by exposure to asbestos are not unique, except that a chest X-ray of an exposed patient with lung cancer may show pleural plaques, pleural calcification, or pleural fibrosis. Symptoms characteristic of mesothelioma include shortness of breath, pain in the walls of the chest, or abdominal pain. Mesothelioma has a much longer latency period compared with lung cancer (40 years versus 15-20 years), and mesothelioma is therefore more likely to be found among workers who were first exposed to asbestos at an early age. Mesothelioma is always fatal.

Asbestosis is pulmonary tibrosis caused by the accumulation of asbestos fibers in the lungs. Symptoms include shortness of breath, coughing, fatigue, and vague feelings of sickness. When the fibrosis worsens, shortness of breath occurs even at rest. The diagnosis of asbestosis is based on a history of exposure to asbestos, the presence of characteristics radiologic changes, end-inspiratory crackles (rales), and other clinical features of fibrosing lung disease. Pleural plaques and thickening are observed on X-rays taken during the early stages of the disease. Asbestosis is often a progressive disease even in the absence of continued exposure, although this appears to be a highly individualized characteristic. In severe cases, death may be caused by respiratory or cardiac failure.

IV. Surveillance and Preventive Considerations

As noted above, exposure to asbestos has been linked to an increased risk of lung cancer, mesothelioma, gastrointestinal cancer, and asbestosis among occupationally exposed workers. Adequate screening tests to determine an employee's potential for developing serious chronic diseases, such as a cancer, from exposure to asbestos do not presently exist. However, some tests, particularly chest X-rays and pulmonary function tests, may indicate that an employee has been overexposed to asbestos, increasing his or her risk of developing exposure related chronic diseases. It is important for the physician to become familiar with the operating conditions in which occupational exposure to asbestos is likely to occur. This is particularly important in evaluating medical and work histories and in conducting physical examinations. When an active employee has been identified as having been overexposed to asbestos measures taken by the employer to eliminate or mitigate further exposure should also lower the risk of serious long-term consequences.

The employer is required to institute a medical surveillance program for all employees who are or will be exposed to asbestos at or above the permissible exposure limit (0.1 fiber per cubic centimeter of air). All examinations and procedures must be performed by or under the supervision of a licensed physician, at a reasonable time and place, and at no cost to the employee.

Although broad latitude is given to the physician in prescribing specific tests to be included in the medical surveillance program, OSHA requires inclusion of the following elements in the routine examination:

(i) Medical and work histories with special emphasis directed to symptoms of the respiratory system, cardiovascular system, and digestive tract.

(ii) Completion of the respiratory disease questionnaire contained in Appendix D.

(iii) A physical examination including a chest roentgenogram and pulmonary function test that includes measurement of the employee's forced vital capacity (FVC) and forced expiratory volume at one second (FEV1).

(iv) Any laboratory or other test that the examining physician deems by sound medical practice to be necessary.

The employer is required to make the prescribed tests available at least annually to those employees covered; more often than specified if recommended by the examining physician; and upon termination of employment.

The employer is required to provide the physician with the following information: A copy of this standard and appendices; a description of the employee's duties as they relate to asbestos exposure; the employee's representative level of exposure to asbestos; a description of any personal protective and respiratory equipment used; and information from previous medical examinations of the affected employee that is not otherwise available to the physician. Making this information available to the physician will aid in the evaluation of the employee's health in relation to assigned duties and fitness to wear personal protective equipment, if required.

The employer is required to obtain a written opinion from the examining physician containing the results of the medical examination; the physician's opinion as to whether the employee has any detected medical conditions that would place the employee at an increased risk of exposure-related disease; any recommended limitations on the employee or on the use of personal protective equipment; and a statement that the employee has been informed by the physician of the results of the medical examination and of any medical conditions related to asbestos exposure that require further explanation or treatment. This written opinion must not reveal specific findings or diagnoses unrelated to exposure to asbestos and a copy of the opinion must be provided to the affected employee.

[59 FR 40964, Aug. 10, 1994]

**Appendix J to 29 CFR 1926.1101
Smoking Cessation Program Information for Asbestos - Non-mandatory**

The following organizations provide smoking cessation information.

1. The National Cancer Institute operates a toll-free Cancer Information Service (CIS) with trained personnel to help you. Call 1-800-4-CANCER to reach the CIS offices serving your area or write: Office of Cancer Communications,

National Cancer Institute, National Institutes of Health, Building 31, Room 10A24, Bethesda, Maryland, 20892.

2. American Cancer Society, 3340 Peachtree Road, N.E., Atlanta, Georgia 30026, (404)320-3333.

The American Cancer Society (ACS) is a voluntary organization composed of 58 divisions and 3,100 local units. Through "The Great American Smokeout" in November, the annual Cancer Crusade in April, and numerous educational materials, ACS helps people learn about the health hazards of smoking and become successful ex-smokers.

3. American Heart Association, 7320 Greenville Avenue, Dallas, Texas 75231, (214)750-5300.

The American Heart Association (AHA) is a voluntary organization with 130,000 members (physicians, scientists, and laypersons) in 55 state and regional groups. AHA produces a variety of publications and audiovisual materials about the effects of smoking on the heart. AHA also has developed a guidebook for incorporating a weight-control component into smoking cessation programs.

4. American Lung Association, 1740 Broadway, New York, New York 10019, (212)245-8000.

A voluntary organization of 7,500 members (physicians, nurses, and laypersons), the American Lung Association (ALA) conducts numerous public information programs about the health effects of smoking. ALA has 59 state and 85 local units. The organization actively supports legislation and information campaigns for non-smokers' rights and provides help for smokers who want to quit, for example, through "Freedom From Smoking," a self-help smoking cessation program.

5. Office on Smoking and Health, U.S. Department of Health and Human Services, 5600 Fishers Lane, Park Building, Room 110, Rockville, Maryland 20857.

The Office on Smoking and Health (OSH) is the Department of Health and Human Services' lead agency in smoking control. OSH has sponsored distribution of publications on smoking-related topics, such as free flyers on relapse after initial quitting, helping a friend or family member quit smoking, the health hazards of smoking, and the effects of parental smoking on teenagers.

- In Hawaii, on Oahu call 524-1234 (call collect from neighboring islands).

Spanish-speaking staff members are available during daytime hours to callers from the following areas: California, Florida, Georgia, Illinois, New Jersey (area code 201), New York, and Texas. Consult your local telephone directory for listings of local chapters.

[59 FR 40964, Aug. 10, 1994]

Appendix K to 29 CFR 1926.1101 Polarized Light Microscopy of Asbestos—Non-Mandatory

Method number:

ID-191
Matrix: Bulk
Collection Procedure:

Collect approximately 1 to 2 grams of each type of material and place into separate 20 mL scintillation vials.

Analytical Procedure:

A portion of each separate phase is analyzed by gross examination, phase-polar examination, and central stop dispersion microscopy.

Commercial manufacturers and products mentioned in this method are for descriptive use only and do not constitute endorsements by USDOL-OSHA. Similar products from other sources may be substituted.

1. Introduction

This method describes the collection and analysis of asbestos bulk materials by light microscopy techniques including phase-polar illumination and central-stop dispersion microscopy. Some terms unique to asbestos analysis are defined below:

Amphibole: A family of minerals whose crystals are formed by long, thin units which have two thin ribbons of double chain silicate with a brucite ribbon in between. The shape of each unit is similar to an "I beam". Minerals important in asbestos analysis include cummingtonite-grunerite, crocidolite, tremolite-actinolite and anthophyllite.

Asbestos: A term for naturally occurring fibrous minerals. Asbestos includes chrysotile, cummingtonite-grunerite asbestos (amosite), anthophyllite asbestos, tremolite asbestos, crocidolite, actinolite asbestos and any of these minerals which have been chemically treated or altered. The precise chemical formulation of each species varies with the location from which it was mined. Nominal compositions are listed:

Chrysotile:
$Mg_3Si_2O_5(OH)_4$

Crocidolite (Riebeckite asbestos):
$Na_2Fe_3{}^2+Fe_3{}^2+Si_8O_{22}(OH)_2$

Cummingtonite-Grunerite asbestos (Amosite): $(Mg,Fe)_7Si_8O_{22}(OH)_2$

Tremolite-Actinolite asbestos:
$Ca_2(Mg,Fe)_5Si_8O_{22}(OH)_2$

Anthophyllite asbestos:
$(Mg,Fe)_7Si_8O_{22}(OH)_2$

Asbestos Fiber: A fiber of asbestos meeting the criteria for a fiber. (See section 3.5. of this Appendix)

Aspect Ratio: The ratio of the length of a fiber to its diameter usually defined as “length : width”, e.g. 3:1.

Brucite: A sheet mineral with the composition $Mg(OH)_2$.

Central Stop Dispersion Staining (microscope): This is a dark field microscope technique that images particles using only light refracted by the particle, excluding light that travels through the particle unrefracted. This is usually accomplished with a McCrone objective or other arrangement which places a circular stop with apparent aperture equal to the objective aperture in the back focal plane of the microscope.

Cleavage Fragments: Mineral particles formed by the comminution of minerals, especially those characterized by relatively parallel sides and moderate aspect ratio.

Differential Counting: The term applied to the practice of excluding certain kinds of fibers from a phase contrast asbestos count because they are not asbestos.

Fiber: A particle longer than or equal to 5 um with a length to width ratio greater than or equal to 3:1. This may include cleavage fragments. (see section 3.5 of this appendix).

Phase Contrast: Contrast obtained in the microscope by causing light scattered by small particles to destructively interfere with unscattered light, thereby enhancing the visibility of very small particles and particles with very low intrinsic contrast.

Phase Contrast Microscope: A microscope configured with a phase mask pair to create phase contrast. The technique which uses this is called Phase Contrast Microscopy (PCM).

Phase-Polar Analysis: This is the use of polarized light in a phase contrast microscope. It is used to see the same size fibers that are visible in air filter analysis. Although fibers finer than 1 um are visible, analysis of these is inferred from analysis of larger bundles that are usually present.

Phase-Polar Microscope: The phase-polar microscope is a phase contrast microscope which has an analyzer, a polarizer, a first order red plate and a rotating phase condenser all in place so that the polarized light image is enhanced by phase contrast.

Sealing Encapsulant: This is a product which can be applied, preferably by spraying, onto an asbestos surface which will seal the surface so that fibers cannot be released.

Serpentine: A mineral family consisting of minerals with the general composition $Mg_3Si_2O_5(OH)_4$ having the magnesium in brucite layer over a silicate layer. Minerals important in asbestos analysis included in this family are chrysotile, lizardite, antigorite.

1.1. History

Light microscopy has been used for well over 100 years for the determination of mineral species. This analysis is carried out using specialized polarizing microscopes as well as bright field microscopes. The identification of minerals is an on-going process with many new minerals described each year. The first recorded use of asbestos was in Finland about 2500 B.C. where the material was used in the mud wattle for the wooden huts the people lived in as well as strengthening for pottery. Adverse health aspects of the mineral were noted nearly 2000 years ago when Pliny the Younger wrote about the poor health of slaves in the asbestos mines. Although known to be injurious for centuries, the first modern references to its toxicity were by the British Labor Inspectorate when it banned asbestos dust from the workplace in 1898. Asbestosis cases were described in the literature after the turn of the century. Cancer was first suspected in the mid 1930's and a causal link to mesothelioma was made in 1965. Because of the public concern for worker and public safety with the use of this material, several different types of analysis were applied to the determination of asbestos content. Light microscopy requires a great deal of experience and craft. Attempts were made to apply less subjective methods to the analysis. X-ray diffraction was partially successful in determining the mineral types but was unable to separate out the fibrous portions from the non-fibrous portions. Also, the minimum detection limit for asbestos analysis by X-ray diffraction (XRD) is about 1%. Differential Thermal Analysis (DTA) was no more successful. These provide useful corroborating information when the presence of asbestos has been shown by microscopy; however, neither can determine the difference between fibrous and non-fibrous minerals when both habits are present. The same is true of Infrared Absorption (IR).

When electron microscopy was applied to asbestos analysis, hundreds of fibers were discovered present too small to be visible in any light microscope. There are two different types of electron microscope used for asbestos analysis: Scanning Electron Microscope (SEM) and Transmission Electron Microscope (TEM). Scanning Electron Microscopy is useful in identifying minerals. The SEM can provide two of the three pieces of information required to identify fibers by electron microscopy: morphology and chemistry. The third is structure as determined by Selected Area Electron Diffraction -- SAED which is performed in the TEM. Although the resolution of the SEM is sufficient for very fine fibers to be seen, accuracy of chemical analysis that can be performed on the fibers varies with fiber diameter in fibers of less than 0.2 um diameter. The TEM is a powerful tool to identify fibers too small to be resolved by light microscopy and should be used in conjunction with this method when necessary. The TEM can provide all three pieces of information required for fiber identification. Most fibers thicker than 1 um can adequately be defined in the light microscope. The light microscope remains as the best instrument for the determination of mineral type. This is because the minerals under investigation were first described analytically with the light microscope. It is inexpensive and gives positive identification for most samples analyzed. Further, when optical techniques are inadequate, there is ample indication that alternative techniques should be used for complete identification of the sample.

1.2. Principle

Minerals consist of atoms that may be arranged in random order or in a regular arrangement. Amorphous materials have atoms in random order while crystalline materials have long range order. Many materials are transparent to light, at least for small particles or for thin sections. The properties of these materials can be investigated by the effect that the material has on light passing through it. The six asbestos minerals are all crystalline with particular properties that have been identified and cataloged. These six minerals are anisotropic. They have a regular array of atoms, but the arrangement is not the same in all directions. Each major direction of the crystal presents a different regularity. Light photons traveling in each of these main directions will encounter different electrical neighborhoods, affecting the path and time of travel. The techniques outlined in this method use the fact that light traveling through fibers or crystals in different directions will behave differently, but predictably. The behavior of the light as it travels through a crystal can be measured and compared with known or determined values to identify the mineral species. Usually, Polarized Light Microscopy (PLM) is performed with strain-free objectives on a bright-field microscope platform. This would limit the resolution of the microscope to about 0.4 um. Because OSHA requires the counting and identification of fibers visible in phase contrast, the phase contrast platform is used to visualize the fibers with the polarizing elements added into the light path. Polarized light methods cannot identify fibers finer than about 1 um in diameter even though they are visible. The finest fibers are usually identified by inference from the presence of larger, identifiable fiber bundles. When fibers are present, but not identifiable by light microscopy, use either SEM or TEM to determine the fiber identity.

1.3. Advantages and Disadvantages

The advantages of light microcopy are:

(a) Basic identification of the materials was first performed by light microscopy and gross analysis. This provides a large base of published information against which to check analysis and analytical technique.

(b) The analysis is specific to fibers. The minerals present can exist in asbestiform, fibrous, prismatic, or massive varieties all at the same time. Therefore, bulk methods of analysis such as X-ray diffraction, IR analysis, DTA, etc. are inappropriate where the material is not known to be fibrous.

(c) The analysis is quick, requires little preparation time, and can be performed on-site if a suitably equipped microscope is available.

The disadvantages are:

(a) Even using phase-polar illumination, not all the fibers present may be seen. This is a problem for very low asbestos concentrations where agglomerations or large bundles of fibers may not be present to allow identification by inference.

(b) The method requires a great degree of sophistication on the part of the microscopist. An analyst is only as useful as his mental catalog of images. Therefore, a microscopist's accuracy is enhanced by experience. The mineralogical training of the analyst is very important. It is the basis on which subjective decisions are made.

(c) The method uses only a tiny amount of material for analysis. This may lead to sampling bias and false results (high or low). This is especially true if the sample is severely inhomogeneous.

(d) Fibers may be bound in a matrix and not distinguishable as fibers so identification cannot be made.

1.4. Method Performance

1.4.1. This method can be used for determination of asbestos content from 0 to 100% asbestos. The detection limit has not been adequately determined, although for selected samples, the limit is very low, depending on the number of particles examined. For mostly homogeneous, finely divided samples, with no difficult fibrous interferences, the detection limit is below 1%. For inhomogeneous samples (most samples), the detection limit remains undefined. NIST has conducted proficiency testing of laboratories on a national scale. Although each round is reported statistically with an average, control limits, etc., the results indicate a difficulty in establishing precision especially in the low concentration range. It is suspected that there is significant bias in the low range especially near 1%. EPA tried to remedy this by requiring a mandatory point counting scheme for samples less than 10%. The point counting procedure is tedious, and may introduce significant biases of its own. It has not been incorporated into this method.

1.4.2. The precision and accuracy of the quantitation tests performed in this method are unknown. Concentrations are easier to determine in commercial products where asbestos was deliberately added because the amount is usually more than a few percent. An analyst's results can be "calibrated" against the known amounts added by the manufacturer. For geological samples, the degree of homogeneity affects the precision.

1.4.3. The performance of the method is analyst dependent. The analyst must choose carefully and not necessarily randomly the portions for analysis to assure that detection of asbestos occurs when it is present. For this reason, the analyst must have adequate training in sample preparation, and experience in the location and identification of asbestos in samples. This is usually accomplished through substantial on-the-job training as well as formal education in mineralogy and microscopy.

1.5. Interferences

Any material which is long, thin, and small enough to be viewed under the microscope can be considered an interference for asbestos. There are literally hundreds of interferences in workplaces. The techniques described in this method are normally sufficient to eliminate the interferences. An analyst's success in eliminating the interferences depends on proper training.

Asbestos minerals belong to two mineral families: the serpentines and the amphiboles. In the serpentine family, the only common fibrous mineral is chrysotile. Occasionally, the mineral antigorite occurs in a fibril habit with morphology similar to the amphiboles. The amphibole minerals consist of a score of different minerals of which only five are regulated by federal standard: amosite, crocidolite, anthophyllite asbestos, tremolite asbestos and actinolite asbestos. These are the only amphibole minerals that have been commercially exploited for their fibrous properties; however, the rest can and do occur occasionally in asbestiform habit.

In addition to the related mineral interferences, other minerals common in building material may present a problem for some microscopists: gypsum, anhydrite, brucite, quartz fibers, talc fibers or ribbons, wollastonite, perlite, attapulgite, etc. Other fibrous materials commonly present in workplaces are: fiberglass, mineral wool, ceramic wool, refractory ceramic fibers, kevlar, nomex, synthetic fibers, graphite or carbon fibers, cellulose (paper or wood) fibers, metal fibers, etc.

Matrix embedding material can sometimes be a negative interference. The analyst may not be able to easily extract the fibers from the matrix in order to use the method. Where possible, remove the matrix before the analysis, taking careful note of the loss of weight. Some common matrix materials are: vinyl, rubber, tar, paint, plant fiber, cement, and epoxy. A further negative interference is that the asbestos fibers themselves may be either too small to be seen in Phase contrast Microscopy (PCM) or of a very low fibrous quality, having the appearance of plant fibers. The analyst's ability to deal with these materials increases with experience.

1.6. Uses and Occupational Exposure

Asbestos is ubiquitous in the environment. More than 40% of the land area of the United States is composed of minerals which may contain asbestos. Fortunately, the actual formation of great amounts of asbestos is relatively rare. Nonetheless, there are locations in which environmental exposure can be severe such as in the Serpentine Hills of California.

There are thousands of uses for asbestos in industry and the home. Asbestos abatement workers are the most current segment of the population to have occupational exposure to great amounts of asbestos. If the material is undisturbed, there is no exposure. Exposure occurs when the asbestos-containing material is abraded or otherwise disturbed during maintenance operations or some other activity. Approximately 95% of the asbestos in place in the United States is chrysotile.

Amosite and crocidolite make up nearly all the difference. Tremolite and anthophyllite make up a very small percentage. Tremolite is found in extremely small amounts in certain chrysotile deposits. Actinolite exposure is probably greatest from environmental sources, but has been identified in vermiculite containing, sprayed-on insulating materials which may have been certified as asbestos-free.

1.7. Physical and Chemical Properties

The nominal chemical compositions for the asbestos minerals were given in Section 1. Compared to cleavage fragments of the same minerals, asbestiform fibers possess a high tensile strength along the fiber axis. They are chemically inert, non-combustible, and heat resistant. Except for chrysotile, they are insoluble in Hydrochloric acid (HCl). Chrysotile is slightly soluble in HCl. Asbestos has high electrical resistance and good sound absorbing characteristics. It can be woven into cables, fabrics or other textiles, or matted into papers, felts, and mats.

1.8. Toxicology (This Section is for Information Only and Should Not Be Taken as OSHA Policy)

Possible physiologic results of respiratory exposure to asbestos are mesothelioma of the pleura or peritoneum, interstitial fibrosis, asbestosis, pneumoconiosis, or respiratory cancer. The possible consequences of asbestos exposure are detailed in the NIOSH Criteria Document or in the OSHA Asbestos Standards 29 CFR 1910.1001 and 29 CFR 1926.1101 and 29 CFR 1915.1001.

2. Sampling Procedure

2.1. Equipment for sampling

(a) Tube or cork borer sampling device
(b) Knife
(c) 20 mL scintillation vial or similar vial
(d) Sealing encapsulant

2.2. Safety Precautions

Asbestos is a known carcinogen. Take care when sampling. While in an asbestos-containing atmosphere, a properly selected and fit-tested respirator should be worn. Take samples in a manner to cause the least amount of dust. Follow these general guidelines:

(a) Do not make unnecessary dust.
(b) Take only a small amount (1 to 2 g).
(c) Tightly close the sample container.
(d) Use encapsulant to seal the spot where the sample was taken, if necessary.

2.3. Sampling Procedure

Samples of any suspect material should be taken from an inconspicuous place. Where the material is to remain, seal the sampling wound with an encapsulant to eliminate the potential for exposure from the sample site. Microscopy requires only a few milligrams of material. The amount that will fill a 20 mL scintillation vial is more than adequate. Be sure to collect samples from all layers and phases of material. If possible, make separate samples of each different phase of the material. This will aid in determining the actual hazard. DO NOT USE ENVELOPES, PLASTIC OR PAPER BAGS OF ANY KIND TO COLLECT SAMPLES. The use of plastic bags presents a contamination hazard to laboratory personnel and to other samples. When these containers are opened, a bellows effect blows fibers out of the container onto everything, including the person opening the container.

If a cork-borer type sampler is available, push the tube through the material all the way, so that all layers of material are sampled. Some samplers are intended to be disposable. These should be capped and sent to the laboratory. If a non-disposable cork borer is used, empty the contents into a scintillation vial and send to the laboratory. Vigorously and completely clean the cork borer between samples.

2.4. Shipment

Samples packed in glass vials must not touch or they might break in shipment.

(a) Seal the samples with a sample seal over the end to guard against tampering and to identify the sample.

(b) Package the bulk samples in separate packages from the air samples. They may cross-contaminate each other and will invalidate the results of the air samples.

(c) Include identifying paperwork with the samples, but not in contact with the suspected asbestos.

(d) To maintain sample accountability, ship the samples by certified mail, overnight express, or hand carry them to the laboratory.

3. Analysis

The analysis of asbestos samples can be divided into two major parts: sample preparation and microscopy. Because of the different asbestos uses that may be encountered by the analyst, each sample may need different preparation steps. The choices are outlined below. There are several different tests that are performed to identify the asbestos species and determine the percentage. They will be explained below.

3.1. Safety

(a) Do not create unnecessary dust. Handle the samples in HEPA-filter equipped hoods. If samples are received in bags, envelopes or other inappropriate container, open them only in a hood having a face velocity at or greater than 100 fpm. Transfer a small amount to a scintillation vial and only handle the smaller amount.

(b) Open samples in a hood, never in the open lab area.

(c) Index of refraction oils can be toxic. Take care not to get this material on the skin. Wash immediately with soap and water if this happens.

(d) Samples that have been heated in the muffle furnace or the drying oven may be hot. Handle them with tongs until they are cool enough to handle.

(e) Some of the solvents used, such as THF (tetrahydrofuran), are toxic and should only be handled in an appropriate fume hood and according to instructions given in the Material Safety Data Sheet (MSDS).

3.2. Equipment

(a) Phase contrast microscope with 10x, 16x and 40x objectives, 10x wide-field eyepieces, G-22 Walton-Beckett graticule, Whipple disk, polarizer, analyzer and first order red or gypsum plate, 100 Watt illuminator, rotating position condenser with oversize phase rings, central stop dispersion objective, Kohler illumination and a rotating mechanical stage.

(b) Stereo microscope with reflected light illumination, transmitted light illumination, polarizer, analyzer and first order red or gypsum plate, and rotating stage.

(c) Negative pressure hood for the stereo microscope

(d) Muffle furnace capable of 600 deg.C

(e) Drying oven capable of 50 -- 150 deg.C

(f) Aluminum specimen pans

(g) Tongs for handling samples in the furnace

(h) High dispersion index of refraction oils (Special for dispersion staining.)

n = 1.550

n = 1.585

n = 1.590

n = 1.605

n = 1.620

n = 1.670

n = 1.680

n = 1.690

(i) A set of index of refraction oils from about n = 1.350 to n = 2.000 in n = 0.005 increments. (Standard for Becke line analysis.)

(j) Glass slides with painted or frosted ends 1x3 inches 1mm (thick, precleaned.)

(k) Cover Slips 22x22 mm, #1 1/2

(l) Paper clips or dissection needles

(m) Hand grinder

(n) Scalpel with both #10 and #11 blades

(o) 0.1 molar HCl

(p) Decalcifying solution (Baxter Scientific Products) Ethylenediaminetetraacetic Acid,

Tetrasodium . . . . 0.7 g/l
Sodium Potassium Tartrate . . 8.0 mg/liter
Hydrochloric Acid . . . . 99.2 g/liter
Sodium Tartrate . . . . 0.14 g/liter

(q) Tetrahydrofuran (THF)

(r) Hotplate capable of 60 deg.C

(s) Balance

(t) Hacksaw blade

(u) Ruby mortar and pestle

3.3. Sample Pre-Preparation

Sample preparation begins with pre-preparation which may include chemical reduction of the matrix, heating the sample to dryness or heating in the muffle furnace. The end result is a sample which has been reduced to a powder that is sufficiently fine to fit under the cover slip. Analyze different phases of samples separately, e.g., tile and the tile mastic should be analyzed separately as the mastic may contain asbestos while the tile may not.

(a) Wet Samples

Samples with a high water content will not give the proper dispersion colors and must be dried prior to sample mounting. Remove the lid of the scintillation vial, place the bottle in the drying oven and heat at 100 deg.C to dryness (usually about 2 h). Samples which are not submitted to the lab in glass must be removed and placed in glass vials or aluminum weighing pans before placing them in the drying oven.

(b) Samples With Organic Interference -- Muffle Furnace

These may include samples with tar as a matrix, vinyl asbestos tile, or any other organic that can be reduced by heating. Remove the sample from the vial and weigh in a balance to determine the weight of the submitted portion. Place the sample in a muffle furnace at 500 deg.C for 1 to 2 h or until all obvious organic material has been removed. Retrieve, cool and weigh again to determine the weight loss on ignition. This is necessary to determine the asbestos content of the submitted sample, because the analyst will be looking at a reduced sample.

Note: Heating above 600 deg.C will cause the sample to undergo a structural change which, given sufficient time, will convert the chrysotile to forsterite. Heating even at lower temperatures for 1 to 2 h may have a measurable effect on the optical properties of the minerals. If the analyst is unsure of what to expect, a sample of standard asbestos should be heated to the same temperature for the same length of time so that it can be examined for the proper interpretation.

(c) Samples With Organic Interference -- THF

Vinyl asbestos tile is the most common material treated with this solvent, although, substances containing tar will sometimes yield to this treatment. Select a portion of the material and then grind it up if possible. Weigh the sample and place it in a test tube. Add sufficient THF to dissolve the organic matrix. This is usually about 4 to 5 mL. Remember, THF is highly flammable. Filter the remaining material through a tared silver membrane, dry and weigh to determine how much is left after the solvent extraction. Further process the sample to remove carbonate or mount directly.

(d) Samples With Carbonate Interference

Carbonate material is often found on fibers and sometimes must be removed in order to perform dispersion microscopy. Weigh out a portion of the material and place it in a test tube. Add a sufficient amount of 0.1 M HCl or decalcifying solution in the tube to react all the carbonate as evidenced by gas formation; i.e., when the gas bubbles stop, add a little more solution. If no more gas forms, the reaction is complete. Filter the material out through a tared silver membrane, dry and weigh to determine the weight lost.

3.4. Sample Preparation

Samples must be prepared so that accurate determination can be made of the asbestos type and amount present. The following steps are carried out in the low-flow hood (a low-flow hood has less than 50 fpm flow):

(1) If the sample has large lumps, is hard, or cannot be made to lie under a cover slip, the grain size must be reduced. Place a small amount between two slides and grind the material between them or grind a small amount in a clean mortar and pestle. The choice of whether to use an alumina, ruby, or diamond mortar depends on the hardness of the material. Impact damage can alter the asbestos mineral if too much mechanical shock occurs. (Freezer mills can completely destroy the observable crystallinity of asbestos and should not be used). For some samples, a portion of material can be shaved off with a scalpel, ground off with a hand grinder or hack saw blade.

The preparation tools should either be disposable or cleaned thoroughly. Use vigorous scrubbing to loosen the fibers during the washing. Rinse the implements with copious amounts of water and air-dry in a dust-free environment.

(2) If the sample is powder or has been reduced as in (1) above, it is ready to mount. Place a glass slide on a piece of optical tissue and write the identification on the painted or frosted end. Place two drops of index of refraction medium n = 1.550 on the slide. (The medium n = 1.550 is chosen because it is the matching index for chrysotile. Dip the end of a clean paper-clip or dissecting needle into the droplet of refraction medium on the slide to moisten it. Then dip the probe into the powder sample. Transfer what sticks on the probe to the slide. The material on the end of the probe should have a diameter of about 3 mm for a good mount. If the material is very fine, less sample may be appropriate. For non-powder samples such as fiber mats, forceps should be used to transfer a small amount of material to the slide. Stir the material in the medium on the slide, spreading it out and making the preparation as uniform as possible. Place a cover-slip on the preparation by gently lowering onto the slide and allowing it to fall "trapdoor" fashion on the preparation to push out any bubbles. Press gently on the cover slip to even out the distribution of particulate on the slide. If there is insufficient mounting oil on the slide, one or two drops may be placed near the edge of the coverslip on the slide. Capillary action will draw the necessary amount of liquid into the preparation. Remove excess oil with the point of a laboratory wiper.

Treat at least two different areas of each phase in this fashion. Choose representative areas of the sample. It may be useful to select particular areas or fibers for analysis. This is useful to identify asbestos in severely inhomogeneous samples.

When it is determined that amphiboles may be present, repeat the above process using the appropriate high-dispersion oils until an identification is made or all six asbestos minerals have been ruled out. Note that percent determination must be done in the index medium 1.550 because amphiboles tend to disappear in their matching mediums.

3.5. Analytical procedure

Note: This method presumes some knowledge of mineralogy and optical petrography.

The analysis consists of three parts: The determination of whether there is asbestos present, what type is present and the determination of how much is present. The general flow of the analysis is:

(1) Gross examination.

(2) Examination under polarized light on the stereo microscope.

(3) Examination by phase-polar illumination on the compound phase microscope.

(4) Determination of species by dispersion stain. Examination by Becke line analysis may also be used; however, this is usually more cumbersome for asbestos determination.

(5) Difficult samples may need to be analyzed by SEM or TEM, or the results from those techniques combined with light microscopy for a definitive identification.

Identification of a particle as asbestos requires that it be asbestiform. Description of particles should follow the suggestion of Campbell. (Figure 1)

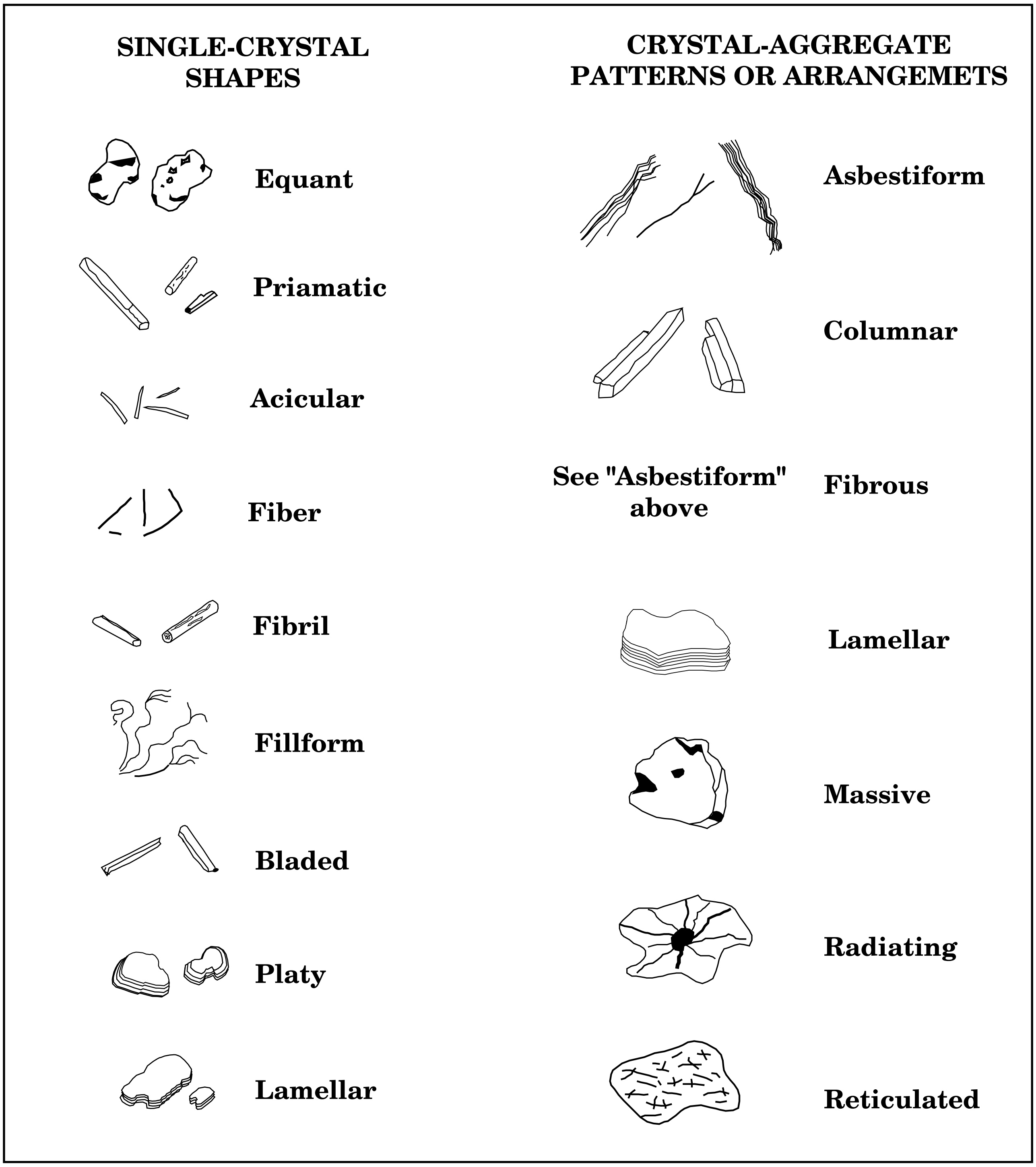

Figure 1. Particle definitions showing mineral growth habits from the U.S. Bureau of Mines.

For the purpose of regulation, the mineral must be one of the six minerals covered and must be in the asbestos growth habit. Large specimen samples of asbestos generally have the gross appearance of wood. Fibers are easily parted from it. Asbestos fibers are very long compared with their widths. The fibers have a very high tensile strength as demonstrated by bending without breaking. Asbestos fibers exist in bundles that are easily parted, show longitudinal fine structure and may be tufted at the ends showing "bundle of sticks" morphology. In the microscope some of these properties may not be observable. Amphiboles do not always show striations along their length even when they are asbestos. Neither will they always show tufting. They generally do not show a curved nature except for very long fibers. Asbestos and asbestiform minerals are usually characterized in groups by extremely high aspect ratios (greater than 100:1). While aspect ratio analysis is useful for characterizing populations of fibers, it cannot be used to identify individual fibers of intermediate to short aspect ratio. Observation of many fibers is often necessary to determine whether a sample consists of "cleavage fragments" or of asbestos fibers.

Most cleavage fragments of the asbestos minerals are easily distinguishable from true asbestos fibers. This is because true cleavage fragments usually have larger diameters than 1 um. Internal structure of particles larger than this usually shows them to have no internal fibrillar structure. In addition, cleavage fragments of the monoclinic amphiboles show inclined extinction under crossed polars with no compensator. Asbestos fibers usually show extinction at zero degrees or ambiguous extinction if any at all. Morphologically, the larger cleavage fragments are obvious by their blunt or stepped ends showing prismatic habit. Also, they tend to be acicular rather than filiform.

Where the particles are less than 1 um in diameter and have an aspect ratio greater than or equal to 3:1, it is recommended that the sample be analyzed by SEM or TEM if there is any question whether the fibers are cleavage fragments or asbestiform particles.

Care must be taken when analyzing by electron microscopy because the interferences are different from those in light microscopy and may structurally be very similar to asbestos. The classic interference is between anthophyllite and biopyribole or intermediate fiber. Use the same morphological clues for electron microscopy as are used for light microscopy, e.g. fibril splitting, internal longitudinal striation, fraying, curvature, etc.

(1) Gross examination:

Examine the sample, preferably in the glass vial. Determine the presence of any obvious fibrous component. Estimate a percentage based on previous experience and current observation. Determine whether any pre-preparation is necessary. Determine the number of phases present. This step may be carried out or augmented by observation at 6 to 40 x under a stereo microscope.

(2) After performing any necessary pre-preparation, prepare slides of each phase as described above. Two preparations of the same phase in the same index medium can be made side-by-side on the same glass for convenience. Examine with the polarizing stereo microscope. Estimate the percentage of asbestos based on the amount of birefringent fiber present.

(3) Examine the slides on the phase-polar microscopes at magnifications of 160 and 400 x . Note the morphology of the fibers. Long, thin, very straight fibers with little curvature are indicative of fibers from the amphibole family. Curved, wavy fibers are usually indicative of chrysotile. Estimate the percentage of asbestos on the phase-polar microscope under conditions of crossed polars and a gypsum plate. Fibers smaller than 1.0 um in thickness must be identified by inference to the presence of larger, identifiable fibers and morphology. If no larger fibers are visible, electron microscopy should be performed. At this point, only a tentative identification can be made. Full identification must be made with dispersion microscopy. Details of the tests are included in the appendices.

(4) Once fibers have been determined to be present, they must be identified. Adjust the microscope for dispersion mode and observe the fibers. The microscope has a rotating stage, one polarizing element, and a system for generating dark-field dispersion microscopy (see Section 4.6. of this appendix). Align a fiber with its length parallel to the polarizer and note the color of the Becke lines. Rotate the stage to bring the fiber length perpendicular to the polarizer and note the color. Repeat this process for every fiber

or fiber bundle examined. The colors must be consistent with the colors generated by standard asbestos reference materials for a positive identification. In n = 1.550, amphiboles will generally show a yellow to straw-yellow color indicating that the fiber indices of refraction are higher than the liquid. If long, thin fibers are noted and the colors are yellow, prepare further slides as above in the suggested matching liquids listed below:

Type of asbestos	Index of refraction
Chrysotile	n = 1.550
Amosite	n = 1.670 r 1.680
Crocidolite	n = 1.690
Anthophyllite	n = 1.605 and 1.620
Tremolite	n = 1.605 and 1.620
Actinolite	n = 1.620

Where more than one liquid is suggested, the first is preferred; however, in some cases this liquid will not give good dispersion color. Take care to avoid interferences in the other liquid; e.g., wollastonite in n = 1.620 will give the same colors as tremolite. In n = 1.605 wollastonite will appear yellow in all directions. Wollastonite may be determined under crossed polars as it will change from blue to yellow as it is rotated along its fiber axis by tapping on the cover slip. Asbestos minerals will not change in this way.

Determination of the angle of extinction may, when present, aid in the determination of anthophyllite from tremolite. True asbestos fibers usually have 0 deg. extinction or ambiguous extinction, while cleavage fragments have more definite extinction.

Continue analysis until both preparations have been examined and all present species of asbestos are identified. If there are no fibers present, or there is less than 0.1% present, end the analysis with the minimum number of slides (2).

(5) Some fibers have a coating on them which makes dispersion microscopy very difficult or impossible. Becke line analysis or electron microscopy may be performed in those cases. Determine the percentage by light microscopy. TEM analysis tends to overestimate the actual percentage present.

(6) Percentage determination is an estimate of occluded area, tempered by gross observation. Gross observation information is used to make sure that the high magnification microscopy does not greatly over- or under-estimate the amount of fiber present. This part of the analysis requires a great deal of experience. Satisfactory models for asbestos content analysis have not yet been developed, although some models based on metallurgical grain-size determination have found some utility. Estimation is more easily handled in situations where the grain sizes visible at about 160 x are about the same and the sample is relatively homogeneous.

View all of the area under the cover slip to make the percentage determination. View the fields while moving the stage, paying attention to the clumps of material. These are not usually the best areas to perform dispersion microscopy because of the interference from other materials. But, they are the areas most likely to represent the accurate percentage in the sample. Small amounts of asbestos require slower scanning and more frequent analysis of individual fields.

Report the area occluded by asbestos as the concentration. This estimate does not generally take into consideration the difference in density of the different species present in the sample. For most samples this is adequate. Simulation studies with similar materials must be carried out to apply microvisual estimation for that purpose and is beyond the scope of this procedure.

(7) Where successive concentrations have been made by chemical or physical means, the amount reported is the percentage of the material in the "as submitted" or original state. The percentage determined by microscopy is multiplied by the fractions remaining after pre-preparation steps to give the percentage in the original sample. For example:

Step 1. 60% remains after heating at 550 deg.C for 1 h.

Step 2. 30% of the residue of step 1 remains after dissolution of carbonate in 0.1 m HCl.

Step 3. Microvisual estimation determines that 5% of the sample is chrysotile asbestos.

The reported result is:

R = (Microvisual result in percent) x (Fraction remaining after step 2) x (Fraction remaining of original sample after step 1)

R = (5) x (.30) x (.60) = 0.9%

(8) Report the percent and type of asbestos present. For samples where asbestos was identified, but is less than 1.0%, report "Asbestos present, less than 1.0%." There must have been at least two observed fibers or fiber bundles in the two preparations to be reported as present. For samples where asbestos was not seen, report as "None Detected."

Auxiliary Information

Because of the subjective nature of asbestos analysis, certain concepts and procedures need to be discussed in more depth. This information will help the analyst understand why some of the procedures are carried out the way they are.

4.1. Light

Light is electromagnetic energy. It travels from its source in packets called quanta. It is instructive to consider light as a plane wave. The light has a direction of travel. Perpendicular to this and mutually perpendicular to each other, are two vector components. One is the magnetic vector and the other is the electric vector. We shall only be concerned with the electric vector. In this description, the interaction of the vector and the mineral will describe all the observable phenomena. From a light source such a microscope illuminator, light travels in all different direction from the filament.

In any given direction away from the filament, the electric vector is perpendicular to the direction of travel of a light ray. While perpendicular, its orientation is random about the travel axis. If the electric vectors from all the light rays were lined up by passing the light through a filter that would only let light rays with electric vectors oriented in one direction pass, the light would then be POLARIZED.

Polarized light interacts with matter in the direction of the electric vector. This is the polarization direction. Using this property it is possible to use polarized light to probe different materials and identify them by how they interact with light.

The speed of light in a vacuum is a constant at about 2.99 x 10(8) m/s. When light travels in different materials such as air, water, minerals or oil, it does not travel at this speed. It travels slower. This slowing is a function of both the material through which the light is traveling and the wavelength or frequency of the light. In general, the more dense the material, the slower the light travels. Also, generally, the higher the frequency, the slower the light will travel. The ratio of the speed of light in a vacuum to that in a material is called the index of refraction (n). It is usually measured at 589 nm (the sodium D line). If white light (light containing all the visible wavelengths) travels through a material, rays of longer wavelengths will travel faster than those of shorter wavelengths, this separation is called dispersion. Dispersion is used as an identifier of materials as described in Section 4.6.

4.2. Material Properties

Materials are either amorphous or crystalline. The difference between these two descriptions depends on the positions of the atoms in them. The atoms in amorphous materials are randomly arranged with no long range order. An example of an amorphous material is glass. The atoms in crystalline materials, on the other hand, are in regular arrays and have long range order. Most of the atoms can be found in highly predictable locations. Examples of crystalline material are salt, gold, and the asbestos minerals.

It is beyond the scope of this method to describe the different types of crystalline materials that can be found, or the full description of the classes into which they can fall. However, some general crystallography is provided below to give a foundation to the procedures described.

With the exception of anthophyllite, all the asbestos minerals belong to the monoclinic crystal type. The unit cell is the basic repeating unit of the crystal and for monoclinic crystals can be described as having three unequal sides, two 90 deg. angles and one angle not equal to 90 deg.. The orthorhombic group, of which anthophyllite is a member has three unequal sides and three 90 deg. angles. The unequal sides are a consequence of the complexity of fitting the different atoms into the unit cell. Although the atoms are in a regular array, that array is not symmetrical in all directions. There is long range order in the three major directions of the crystal. However, the order is different in each of the three directions. This has the effect that the index of refraction is different in each of the three directions. Using polarized light, we can investigate the index of refraction in each of the directions and identify the mineral or material under investigation. The indices alpha, beta, and gamma are used to identify the lowest, middle, and highest index of refraction respectively. The x direction, associated with alpha is called the fast axis. Conversely, the z direction is associated with gamma and is the slow direction. Crocidolite has alpha along the fiber length making it "length-fast". The remainder of the asbestos minerals have the gamma axis along the fiber length. They are called "length-slow". This orientation to fiber length is used to aid in the identification of asbestos.

4.3. Polarized Light Technique

Polarized light microscopy as described in this section uses the phase-polar microscope described in Section 3.2. A phase contrast microscope is fitted with two polarizing elements, one below and one above the sample. The polarizers have their polarization directions at right angles to each other. Depending on the tests performed, there may be a compensator between these two polarizing elements. A compensator is a piece of mineral with known properties that "compensates" for some deficiency in the optical train. Light emerging from a polarizing element has its electric vector pointing in the polarization direction of the element. The light will not be subsequently transmitted through a second element set at a right angle to the first element. Unless the light is altered as it passes from one element to the other, there is no transmission of light.

4.4. Angle of Extinction

Crystals which have different crystal regularity in two or three main directions are said to be anisotropic. They have a different index of refraction in each of the main directions. When such a crystal is inserted between the crossed polars, the field of view is no longer dark but shows the crystal in color. The color depends on the properties of the crystal. The light acts as if it travels through the crystal along the optical axes. If a crystal optical axis were lined up along one of the polarizing directions (either the polarizer or the analyzer) the light would appear to travel only in that direction, and it would blink out or go dark. The difference in degrees between the fiber direction and the angle at which it blinks out is called the angle of extinction. When this angle can be measured, it is useful in identifying the mineral. The procedure for measuring the angle of extinction is to first identify the polarization direction in the microscope. A commercial alignment slide can be used to establish the polarization directions or use anthophyllite or another suitable mineral. This mineral has a zero degree angle of extinction and will go dark to extinction as it aligns with the polarization directions. When a fiber of anthophyllite has gone to extinction, align the eyepiece reticle or graticule with the fiber so that there is a visual cue as to the direction of polarization in the field of view. Tape or otherwise secure the eyepiece in this position so it will not shift.

After the polarization direction has been identified in the field of view, move the particle of interest to the center of the field of view and align it with the polarization direction. For fibers, align the fiber along this direction. Note the angular reading of the rotating stage. Looking at the particle, rotate the stage until the fiber goes dark or "blinks out". Again note the reading of the stage. The difference in the first reading and the second is an angle of extinction.

The angle measured may vary as the orientation of the fiber changes about its long axis. Tables of mineralogical data usually report the maximum angle of extinction. Asbestos forming minerals, when they exhibit an angle of extinction, usually do show an angle of extinction close to the reported maximum, or as appropriate depending on the substitution chemistry.

4.5. Crossed Polars with Compensator

When the optical axes of a crystal are not lined up along one of the polarizing directions (either the polarizer or the analyzer) part of the light travels along one axis and part travels along the other visible axis. This is characteristic of birefringent materials.

The color depends on the difference of the two visible indices of refraction and the thickness of the crystal. The maximum difference available is the difference between the alpha and the gamma axes. This maximum difference is usually tabulated as the birefringence of the crystal.

For this test, align the fiber at 45 deg. to the polarization directions in order to maximize the contribution to each of the optical axes. The colors seen are called retardation colors. They arise from the recombination of light which has traveled through the two separate directions of the crystal. One of the rays is retarded behind the other since the light in that direction travels slower. On recombination, some of the colors which make up white light are enhanced by constructive interference and some are suppressed by destructive interference. The result is a color dependent on the difference between the indices and the thickness of the crystal. The proper colors, thicknesses, and retardations are shown on a Michel-Levy chart. The three items, retardation, thickness and birefringence are related by the following relationship:

R = t(n(gamma) - n(alpha))
R = retardation, t = crystal thickness in um, and n(alpha, gamma) = indices of refraction.

Examination of the equation for asbestos minerals reveals that the visible colors for almost all common asbestos minerals and fiber sizes are shades of gray and black. The eye is relatively poor at discriminating different shades of gray. It is very good at discriminating different colors. In order to compensate for the low retardation, a compensator is added to the light train between the polarization elements. The compensator used for this test is a gypsum plate of known thickness and birefringence. Such a compensator when oriented at 45 deg. to the polarizer direction, provides a retardation of 530 nm of the 530 nm wavelength color. This enhances the red color and gives the background a characteristic red to red-magenta color. If this "full-wave" compensator is in place when the asbestos preparation is inserted into the light train, the colors seen on the fibers are quite different. Gypsum, like asbestos has a fast axis and a slow axis. When a fiber is aligned with its fast axis in the same direction as the fast axis of the gypsum plate, the ray vibrating in the slow direction is retarded by both the asbestos and the gypsum. This results in a higher retardation than would be present for either of the two minerals. The color seen is a second order blue. When the fiber is rotated 90 deg. using the rotating stage, the slow direction of the fiber is now aligned with the fast direction of the gypsum and the fast direction of the fiber is aligned with the slow direction of the gypsum. Thus, one ray vibrates faster in the fast direction of the gypsum, and slower in the slow direction of the fiber; the other ray will vibrate slower in the slow direction of the gypsum and faster in the fast direction of the fiber. In this case, the effect is subtractive and the color seen is a first order yellow. As long as the fiber thickness does not add appreciably to the color, the same basic colors will be seen for all asbestos types except crocidolite. In crocidolite the colors will be weaker, may be in the opposite directions, and will be altered by the blue absorption color natural to crocidolite. Hundreds of other materials will give the same colors as asbestos, and therefore, this test is not definitive for asbestos. The test is useful in discriminating against fiberglass or other amorphous fibers such as some synthetic fibers. Certain synthetic fibers will show retardation colors different than asbestos; however, there are some forms of polyethylene and aramid which will show morphology and retardation colors similar to asbestos minerals. This test must be supplemented with a positive identification test when birefringent fibers are present which can not be excluded by morphology. This test is relatively ineffective for use on fibers less than 1 um in diameter. For positive confirmation TEM or SEM should be used if no larger bundles or fibers are visible.

4.6. Dispersion Staining

Dispersion microscopy or dispersion staining is the method of choice for the identification of asbestos in bulk materials. Becke line analysis is used by some laboratories and yields the same results as does dispersion staining for asbestos and can be used in lieu of dispersion staining. Dispersion staining is performed on the same platform as the phase-polar analysis with the analyzer and compensator removed. One polarizing element remains to define the direction of the light so that the different indices of refraction of the fibers may be separately determined. Dispersion microscopy is a dark-field technique when used for asbestos. Particles are imaged with scattered light. Light which is unscattered is blocked from reaching the eye either by the back field image mask in a McCrone objective or a back field image mask in the phase condenser. The most convenient method is to use the rotating phase condenser to move an oversized phase ring into place. The ideal size for this ring is for the central disk to be just larger than the objective entry aperture as viewed in the back focal plane. The larger the disk, the less scattered light reaches the eye. This will have the effect of diminishing the intensity of dispersion color and will shift the actual color seen. The colors seen vary even on microscopes from the same manufacturer. This is due to the different bands of wavelength exclusion by different mask sizes. The mask may either reside in the condenser or in the objective back focal plane. It is imperative that the analyst determine by experimentation with asbestos standards what the appropriate colors should be for each asbestos type. The colors depend also on the temperature of the preparation and the exact chemistry of the asbestos. Therefore, some slight differences from the standards should be allowed. This is not a serious problem for commercial asbestos uses. This technique is used for identification of the indices of refraction for fibers by recognition of color. There is no direct numerical readout of the index of refraction. Correlation of color to actual index of refraction is possible by referral to published conversion tables. This is not necessary for the analysis of asbestos. Recognition of appropriate colors along with the proper morphology are deemed sufficient to identify the commercial asbestos minerals. Other techniques including SEM, TEM, and XRD may be required to provide additional information in order to identify other types of asbestos.

Make a preparation in the suspected matching high dispersion oil, e.g., n = 1.550 for chrysotile. Perform the preliminary tests to determine whether the fibers are birefringent or not. Take note of the morphological character. Wavy fibers are indicative of chrysotile while long, straight, thin, frayed fibers are indicative of amphibole asbestos. This can aid in the selection of the appropriate matching oil. The microscope is set up and the polarization direction is noted as in Section 4.4. Align a fiber with the polarization direction. Note the color. This is the color parallel to the polarizer. Then rotate the fiber rotating the stage 90 deg. so that the polarization direction is across the fiber. This is the perpendicular position. Again note the color. Both colors must be consistent with standard asbestos minerals in the correct direction for a positive identification of asbestos. If only one of the colors is correct while the other is not, the identification is not positive. If the colors in both directions are bluish-white, the analyst has chosen a matching index oil which is higher than the correct matching oil, e.g. the analyst has used n = 1.620 where chrysotile is present. The next lower oil (Section 3.5.) should be used to prepare another specimen. If the color in both directions is yellow-white to straw-yellow-white, this indicates that the index of the oil is lower than the index of the fiber, e.g. the preparation is in n = 1.550 while anthophyllite is present. Select the next higher oil (Section 3.5.) and prepare another slide. Continue in this fashion until a positive identification of all asbestos species present has been made or all possible asbestos species have been ruled out by negative results in this test. Certain plant fibers can have similar dispersion colors as asbestos. Take care to note and evaluate the morphology of the fibers or remove the plant fibers in pre-preparation. Coating material on the fibers such as carbonate or vinyl may destroy the dispersion color. Usually, there will be some outcropping of fiber which will show the colors sufficient for identification. When this is not the case, treat the sample as described in Section 3.3. and then perform dispersion staining. Some samples will yield to Becke line analysis if they are coated or electron microscopy can be used for identification.

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Section
GLOSSARY

ASBESTOS ABATEMENT WORKER REFRESHER

Title

A

ABPO - Asbestos Ban and Phase Out Rule

AC - Asbestos-cement

Accident - An undesirable, unplanned event resulting in personal physical harm, damage to property, or interruption of business. An accident may be the result of an unsafe act or an unsafe condition.

ACGIH - American Conference of Governmental Industrial Hygienists

ACM - Asbestos-containing material

Actinolite - One of six types of asbestos. Actinolite is acid and heat resistant. It was rarely used commercially and made up less than 1% of asbestos production.

Acute effect - Having an immediate response due to a short period of exposure.

A**dministrative control -** An exposure control measure that reduces exposure to an acceptable limit by either removing the worker from exposure after a specific length of time or establishing work rules such as no eating, no drinking, or no smoking.

AFL-CIO - American Federation of Labor and Congress of Industrial Organizations

Aggressive sampling - Air sampling that uses a fan, blower, or broom to simulate activity.

AHERA - Asbestos Hazard Emergency Response Act

Ai**r lock** - A system of enclosures consisting of polyethylene-curtained doorways at least three feet apart. Air locks restrict air movement between clean and contaminated areas while a person is passing through them.

Air monitoring - The process of measuring the airborne asbestos fiber concentration in a specific area over a given time period.

Air purifying respirator - A respirator that removes limited concentrations of air contaminants from the breathing air. They do not add oxygen to the air and cannot be used in an oxygen-deficient atmosphere.

Air sample - Sample of air taken for the purpose of determining a quantity of asbestos fibers found in the air.

Alveoli - Air sacs of the lungs at the end of the bronchioles where oxygen and carbon dioxide are exchanged.

Amended water - Water that has a wetting agent or surfactant added to it. The wetting agent makes the water soak into the material it has been applied to more quickly and thoroughly.

Amosite - A type of asbestos, commonly known as brown asbestos. Amosite has coarse, brownish fibers that are highly acid-resistant. The body of the fiber has a smooth spear-like appearance, and the ends look broken and jagged. Amosite tends to shed water and is difficult to keep wet during abatement projects. It was widely used in ships and pipe and boiler insulation.

Amphibole - A form of asbestos characterized by straight, needle-like fibers.

Anthophyllite - One of six types of asbestos. Anthophyllite is the coarsest asbestos type, is inflexible, and has a low heat resistance. It can only withstand a temperature of 392°F (200°C). A member of the amphibole group, it was used mainly in the chemical industry and rarely in buildings.

Approved landfill - A site for the disposal of asbestos-containing and other hazardous wastes that has been given EPA, state, and local approval.

APR - Air purifying respirator

Area sample - Also called an environmental or stationary air sample. It is used to monitor for a hazardous condition and is taken at a stationary location within the test atmosphere. This sample is not tied to any worker's particular exposure.

Asbestiform - Fibrous minerals that can be classified as a form of asbestos because of their crystal structures and chemical composition.

Asbestos - A group of naturally occurring minerals that separate into fibers of high tensile strength and are resistant to heat, wear, and chemicals. There are six types of asbestos: actinolite, amosite, anthophyllite, chrysotile, crocidolite, and tremolite. Asbestos also refers to any product containing any of these materials that have been chemically treated and/or altered which, after manufacture, are used for products and end uses, such as insulation, textiles, paper, cement sheets, floor tile, wall covering, decorations, coating, sealants, cement pipe and reinforced plastics, and other compounds.

Asbestos abatement - Any activity involving the removal, encapsulation, enclosure, renovation, repair, demolition, or other disturbance of friable asbestos-containing materials.

Asbestos abatement supervisor - Any person who has been specifically licensed or certified as a supervisor by the appropriate site supervisor regulatory agency and is named on the asbestos contractor's license.

Asbestos abatement worker - Any employee of a licensed asbestos contractor who engages in asbestos abatement, who is certified to perform Class I, II, III, or IV asbestos work.

Asbestos contractor - Any person or entity engaged in asbestos abatement as a business and whose employees actually perform the asbestos abatement work.

Asbestos-containing material - Any material containing more than 1% asbestos.

Asbestosis - A lung disease caused by the inhalation of asbestos fibers. It is characterized by chronic and inflammatory growth of fibrous tissue in the alveolar walls of the lungs.

ASHARA - Asbestos School Hazard Abatement Reauthorization Act (of 1990)

Atmosphere supplying respirator - A respirator that supplies clean breathable air (Grade D) to the wearer and does not depend on filters. Includes two types: supplied air respirator and self-contained breathing apparatus.

B

Breathing zone - The area of a room in which a worker breathes as he or she stands, sits, or lies down. For air sampling purposes during an asbestos abatement project, the breathing zone is attached to or near the collar or lapel near the worker's face.

Bridging sealant - An encapsulant that forms a discrete (capable of being distinguished as differing) layer on the surface of asbestos containing materials. Bridging sealants are most commonly applied to thermal system insulation.

Bulk sampling - The technique used to collect samples of suspect materials, such as fireproofing, pipe lagging, and boiler insulation. Bulk sampling is usually done during the building survey/hazard assessment and provides data for control measure decisions.

C

c - Ceiling limit

Carcinogen - A substance that causes cancer.

CCA - Chromated copper arsenate

Ceiling limit - The exposure level that should never be exceeded.

Cementitious - Friable materials that are densely packed, nonfibrous, and able to harden like cement.

CFR - Code of Federal Regulations

Chronic effect - Reaction to a substance occurring years after initial exposure or many repeated exposures over a long period of time.

Chrysotile - A type of asbestos of serpentine variety, also known as white asbestos. It is especially resistant to heat and can withstand temperatures up to 932°F (500°C). It was the most common form of asbestos used in buildings and made up about 90% of the asbestos used in this country.

Cilia - Mucus-covered hairs that extend from the surface of cells in the respiratory tract, i.e. the nose, pharynx, trachea and lungs. They beat rhythmically to remove foreign particles encased in mucus from the respiratory tract.

Class I asbestos work - Activities involving the removal of thermal system insulation and surfacing material that is either asbestos-containing material or presumed asbestos-containing material.

Class II asbestos work - Activities involving the removal of asbestos-containing material or presumed asbestos-containing material that is not thermal system insulation or surfacing material. This includes, but is not limited to, the removal of asbestos-containing wallboard, floor tile and sheeting, roofing and siding shingles, and construction mastics.

Class III asbestos work - Repair and maintenance operations, where asbestos-containing material or presumed asbestos-containing material, including thermal system insulation and surfacing material, is likely to be disturbed.

Class IV asbestos work - Maintenance and custodial activities during which employees contact asbestos-containing material and presumed asbestos-containing material and activities to clean up waste and debris containing asbestos-containing material and presumed asbestos-containing material.

Clean/change room - An uncontaminated area or room that is a part of worker decontamination enclosure system. It has provisions for worker's street clothes and clean protective equipment.

Clearance sampling - Air sampling done at the end of abatement.

Cocarcinogen - An agent that increases the effect of a carcinogen (a cancer-causing substance) and makes the effects more deadly.

Competent person - Per OSHA, an individual who is capable of identifying existing asbestos hazards in the workplace and selecting the appropriate control strategy for asbestos exposure. The competent person also has the authority to take prompt corrective measures to eliminate them. (In addition, for Class I and II work, the competent person is specially trained in a course that meets the criteria of EPA's Model Accreditation Plan for project designer or supervisor, or its equivalent. For Class III and IV work, the competent person is also trained in an operations and maintenance course developed by EPA.)

Confined space - An area that has adequate size and shape to allow a person to enter, has limited openings for workers to enter and exit, and is not designed for continuous human occupancy.

Consultation - Any activity by an individual who is directly involved in the inspection or evaluation of a building for asbestos hazards and/or the development, inspection, monitoring or implementation of an asbestos abatement project, and/or providing industrial hygiene services. This individual is not the building owner or their full-time employee.

Continuous flow valve - One of three types of valves on an atmosphere supplying respirator. The air is continuously supplied to the facepiece at a constant flow rate. This type of valve can allow a negative pressure to exist in the facepiece and uses the greatest volume of supplied air.

Controlled access zone - Per OSHA, an area in which certain work (e.g., overhand bricklaying) may take place without the use of guardrail systems, personal fall arrest systems, or safety net systems. Access to the zone is controlled.

CPSC - Consumer Product Safety Commission

Critical barrier - One or more layers of plastic sealed over all openings into a work area or any other similarly placed physical barrier sufficient to prevent airborne asbestos in a work area from migrating to an adjacent area.

Crocidolite - A type of asbestos, commonly known as "blue asbestos," that was often used as marine insulation aboard ships. Crocidolite is bluish in color with smooth spear-like fibers like amosite. The needle shape of crocidolite fibers enable the fibers to penetrate deeper into body tissues than any other type of asbestos. It is acid resistant, but has a low heat resistance (392°F or 200°C). Crocidolite made up about 3.5% of world asbestos production.

CSHO - Compliance safety and health officer

D

Decontamination area - An enclosed area adjacent and connected to the regulated area. It consists of an equipment room, shower area, and clean room. It is used for the decontamination of workers, materials, and equipment contaminated with asbestos.

Demand valve - One of three types of valves on an atmosphere supplying respirator that delivers air to the facepiece upon inhalation, i.e., the demand of the wearer. Negative pressure can occur in the facepiece for very short periods. Uses the least amount of supplied air.

Demolition - The wrecking or taking out of any load-supporting structural member and any related razing, removing, or stripping of asbestos products.

DHHS - Department of Health and Human Services

Disturbance - Any activity that releases fibers from asbestos-containing material (ACM) or presumed asbestos-containing material (PACM) or debris containing ACM or PACM. This term includes activities that disrupt the matrix of ACM or PACM, render ACM or PACM friable, or generate visible debris. Disturbance includes cutting away small amounts of ACM and PACM, no greater than the amount that can be contained in one standard sized glove bag or waste bag in order to access a building component. In no event shall the amount of ACM or PACM so disturbed exceed that which can be contained in one glove bag or waste bag, which shall not exceed 60 inches in length and width.

DOE - Department of Energy

DOL - Department of Labor

DOT - Department of Transportation

E

EL - Excursion limit

ELSI - End-of-service-life indicator

Emergency asbestos abatement project - Any asbestos abatement project that was not planned, but results from a sudden, unexpected event, including operations by nonroutine failures of equipment.

Employee exposure - The exposure to airborne asbestos that would occur if the employee were not using respiratory protective equipment.

Encapsulation - The application of bonding or sealing agent (encapsulant) to asbestos-containing materials to control the release of asbestos fibers into the air. The encapsulant creates a membrane over the surface (bridging encapsulant) or penetrates the material and binds its components together (penetrating encapsulant) or is a combination of both (hybrid encapsulant).

Enclosure - Construction of airtight walls, ceilings, or barriers around the asbestos-containing material. The purpose of an enclosure is to isolate the asbestos-containing material from the rest of the building and the people in the building.

Engineering control - An exposure control in which exposure is reduced through mechanical means, such as ventilation systems, acoustical materials, or clean air control booths.

EPA - Environmental Protection Agency

EPA Emissions Standards for Asbestos - The EPA law for asbestos requiring "no visible emission" of asbestos during any part of demolition, renovation or asbestos removal work. Also requires the notification of the EPA of such jobs.

Equipment/dirty room - A contaminated area that is the last room of the worker decontamination enclosure system. It has provisions for storage of contaminated clothing and equipment and is sometimes called the dirty room.

ESLI - End-of-service-life indicator

Excursion limit - Per OSHA, the employer shall ensure that no employee is exposed to an airborne concentration of asbestos of 1.0 fiber per cubic centimeter of air (1 f/cc) as averaged over a sampling period of 30 minutes.

F

FAM - Fibrous aerosol monitor

f/cc - Fibers per cubic centimeters of air. (A cubic centimeter is about the size of a sugar cube.)

FEV$_1$ - Forced expiatory volume after one second

Fiber - A particulate form of asbestos, 5 micrometers or longer, with a length-to-diameter ratio of at least 3 to 1.

Fiber concentration - The level of asbestos fibers in the air. Fiber concentration is determined by counting the fibers in a certain volume of air.

Fibrosis - Also called diffuse interstitial fibrosis. A thickening and hardening of the lung tissue, and subsequent loss of normal function, caused by asbestosis.

Fibrous aerosol monitor - A direct reading instrument used to screen for airborne particles such as asbestos fibers. Operates by a laser that counts particles passing through its field. The FAM is not capable of differentiating between particle types, and therefore, may only be used in screening for airborne asbestos fibers.

Filtering facepiece - Also called a dust mask. It is a negative pressure particulate respirator. The filter is an integral part of the facepiece or the entire facepiece is composed of the filtering medium.

Filters - Some respirator cartridges are filters and contain a paper-like filter that removes dusts or particulates from the air.

Forced expiatory volume at one second - A specific test relating to pulmonary function. The measUrement of air that can be expelled from the lungs for one second after breathing fully.

Forced vital capacity - Relating to a pulmonary function test, forced vital capacity is the measurement of air that can be expelled from the lungs after inhaling as fully as possible.

Friable asbestos-containing material - Any material, containing more than 1% asbestos or asbestiform material by weight, applied on the ceilings, walls, structural members, pipe, duct work, or any part of a building structure which, when dry may be crumbled, pulverized or reduced to powder by hand pressure. Flooring, shingles, roofing and any other building materials can become friable during renovation and/or demolition.

Full-face respirator - A respirator with a facepiece that covers from under the chin to the forehead. May be attached to either an air purifying or atmosphere supplying respirator.

FVC - Forced vital capacity

G

GFCI - Ground fault circuit interrupter

Glove bag - Plastic bag-type enclosure placed around asbestos-containing pipe lagging during removal to minimize the number of airborne fibers released into the atmosphere.

Grade "D" breathing air - The type of air required by OSHA to be used by atmosphere supplying respirators. It has requirements for the minimum percent of oxygen; maximum amount of contaminants, such as oil, mists, or carbon monoxide; percentage of humidity; and other purity requirements.

Granular - A material made of many noncohesive particles of approximately the same size, such as sand and loose-fall insulation.

Ground fault circuit interrupter - A device to automatically deenergize a high voltage system component that develops current leakage.

H

Half-face respirator - A respirator with a face piece that covers from under the chin to the bridge of the nose. May be attached to either an air purifying or atmosphere supplying respirator.

Hazardous Materials Identification System - A typical label system used for identifying hazardous materials. The name of the material and related information about target organs and effects, health hazards, physical hazards, route of entry is included.

Hazardous substance or material - Any substance or material that in normal use can be damaging to the health and well-being of workers and the environment.

Hazardous waste - A substance that has been discarded or otherwise designated as a waste material which contains the potential to damage the health and well-being of people and the environment.

Heat stress - A physical disorder caused with excessive exposure to heat. There are four forms of heat stress: heat rash, heat cramps, heat exhaustion, and heat stroke (sunstroke).

HEPA - High efficiency particulate air

High-efficiency particulate air filter - High-efficiency particulate air filtration found in respirators, air cleaners and vacuum systems capable of filtering 0.3 micrometer particles with 99.97% efficiency. Used in asbestos-contaminated environments.

HMIS - Hazardous Materials Identification System

HVAC - Heating, ventilation, and air conditioning

I

IAA - Isoamyl acetate

IDLH - Immediately dangerous to life or health

IH - Industrial hygienist

Immediately dangerous to life or health - An exposure limit in an environment likely to cause death or serious health effects with very short exposures.

Industrial hygienist - A professional qualified by education, training, and experience to recognize, evaluate, and develop controls for occupational health hazards.

Ingestion - A route of entry in which a substance is eaten or swallowed, thus introducing it into the digestive system.

Inhalation - A route of entry in which a substance is breathed in (inhaled), thus introducing it into the respiratory system.

Initial exposure assessment - The personal sampling conducted during the first phases of an abatement project to determine employees' exposure (outside any respirator) to airborne fibers. The purpose of this assessment is to ascertain the expected exposures of the worker.

Intact - A term to describe ACM that has not crumbled, been pulverized, or otherwise deteriorated so that it is no longer likely to be bound with its matrix.

J–K

No entries

L

Latency period - The time between the exposure to a harmful agent and the onset of recognized symptoms. For asbestos-related diseases, this may be as long as 35 years.

LEL - Lower explosive level

LFL - Lower flammable limit

Limiting orifice sampling pump - A pump for collecting air samples where the flow rate is determined by a specially machined hole of a given diameter. Mainly used for area samples and high flow rates, i.e., approximately 10.0 liters/minute.

M

Macrophages - Large white blood cells that become mobile when tissue becomes inflamed. Macrophages surround foreign objects, such as dust particles, that irritate and inflame tissue. They digest the particles using strong acids or enzymes.

Make-up air - Supplied or infiltrated air to offset (make-up) the air that has been exhausted from an area.

Material safety data sheet - A primary source of information describing the hazardous properties of chemical products on a work site. It is usually developed by the chemical manufacturer.

Maximum use concentration - The level of a specific contaminant which, if exceeded, will cause a worker to be exposed above the PEL because of leakage in a respirator.

Mesothelioma - A rare and incurable form of cancer associated with asbestosis. There are two forms: pleural mesothelioma and peritoneal mesothelioma.

mg/m^3 - Milligrams per cubic meter

Micrometer - A unit of length equal to 1 millionth of a meter and 1 thousandth of a millimeter. Also called a micron.

Micron - A unit of length equal to 1 millionth of a meter and 1 thousandth of a meter. Also called a micrometer.

Mixed cellulose ester membrane filters - The type of ~filtering media used to collect air samples of asbestos fibers. It has a pore size of 0.8 microns and is used to chemically clean when performing asbestos analysis.

mm - millimeter

MSDS - Material safety data sheet

MSHA - Mine Safety Health Administration

MUC - Maximum use concentration

N

NEA - Negative exposure assessment

Negative exposure assessment - Per OSHA, a demonstration by the employer that worker exposure during an operation is expected to be consistently below the PEL

Negative pressure - An atmosphere created in a work area enclosure in which the air pressure inside the work area is less than the air pressure outside. Therefore, air moves into the work area rather than out. Airborne fibers will tend to be drawn through the filtration system rather than leak out into the surrounding areas.

NESHAP - National Emission Standards for Hazardous Air Pollutants

NFPA - National Fire Protection Association

NIOSH - National Institute for Occupational Safety and Health

NLRB - National Labor Relations Board

Nonfriable asbestos-containing materials - Any material containing more than 1% asbestos that when dry, cannot be crumbled, pulverized, or reduced to powder by hand pressure.

No visible emissions - The EPA wording for the limiting of the creation of asbestos dust.

O

OSHA - Occupational Safety and Health Administration

OSH Act - Occupational Safety and Health Act of 1970

P

PACM - Presumed asbestos-containing material

PAPR - Powered air purifying respirator

PCM - Phase contrast microscopy

PEL - Permissible exposure limit

Penetrating sealant - An encapsulant that is absorbed by the asbestos-containing material without leaving a discrete surface layer (i.e., (a layer capable of being distinguished as differing). Penetrating sealants work via capillary action.

Peritoneal mesothelioma - One of two forms of mesothelioma. In peritoneal mesothelioma, tumors are made up cells from the peritoneum (the lining of the abdomen).

Peritoneum - The thin membrane that lines the surfaces of the abdominal cavity.

Permissible exposure limit - A legal standard set by OSHA. For asbestos the PEL is 0.1 fiber per cubic centimeter of air as an 8-hour time-weighted average.

Personal protective equipment - Any protective clothing or device used to prevent contact with and exposure to hazards in the workplace.

Personal sample - An air sample taken with a sampling pump that is attached directly to the worker, with the collecting filter and cassette placed in the worker's breathing zone.

PF - Protection factor

PFT - Pulmonary function test

Phase contrast microscopy - An optical microscopic technique used for the counting of fibers in air samples, but which does not distinguish fiber types.

Pleura - Two layers of thin membrane, one surrounding the lungs and the other layer lining the walls of the chest cavity.

Pleural mesothelioma - One of two forms mesothelioma. In pleural mesothelioma, tumors are made up of cells from the pleura.

Pleural plaque - a calcified or hardened formation located on the pleural lining of the chest wall.

PLM - Polarized light microscopy

Pneumoconiosis - A group of lung diseases resulting from inhalation of particles of industrial substances such as asbestos fibers. These particles are permanently deposited in the lung. Examples of pneumoconioses are silicosis from the inhalation of silica dust and asbestosis from the inhalation of asbestos fibers.

Polarized light microscopy - An optical microscope technique used to identify asbestos fibers. This is the most commonly-accepted method for analyzing bulk material samples for the presence of asbestos.

Powered air purifying respirator - A type of air purifying respirator that uses a battery-powered blower to draw air through the filters and into the facepiece. The PAPR has a full-facepiece or a half-facepiece.

PPE - Personal protective equipment

ppm - Parts per million

Pressure demand valve - One of the three types of valves on an atmosphere supplying respirator which delivers air to the facepiece whenever a drop occurs in pressure within the facepiece. This valve never allows a negative pressure to exist in the facepiece and provides the greatest protection factor.

Presumed asbestos-containing material - Thermal system insulation and surfacing material found in buildings constructed no later than 1980.

Protection factor - The score assigned to a respirator based upon the amount of protection it can provide. It is calculated by dividing the concentration of contaminant outside the respirator by the concentration inside the respirator.

Protective clothing - Protective, lightweight garments worn by workers performing asbestos abatement to keep gross contamination off the body.

psi - Pounds per square inch

Pulmonary function test - A test, conducted with a spirometer that determines if the lungs are expanding and contracting normally, and if there is enough air moving into and out of the lungs.

PVC - Polyvinyl chloride

Q

QLFT - Qualitative fit test

QNFT - Quantitative fit test

Qualitative fit test - A test that can be easily performed to test the fit of a respirator to the wearer. Irritant smoke, amyl acetate (banana oil), or saccharin spray are examples of test agents used for the qualitative fit test. Detection of any of these agents determines the fit of a particular respirator.

Quantitative fit test - A test that gives an exact measure of fit of a particular respirator to a particular wearer. The concentration of a substance is measured outside and inside a respirator and a ratio is determined.

R

RACM - Regulated asbestos-containing material

Regulated asbestos-containing material - Environmental Protection Agency's name for any material containing more than

Regulated area - An area established by the employer to demarcate areas where Class I, II, and III asbestos work is conducted and any adjoining area where debris and waste from such asbestos work accumulate. A work area within which airborne concentrations of asbestos exceed, or there is a reasonable possibility they may exceed, the permissible exposure limit.

Removal - All operations where ACM and/or PACM is taken out or stripped from structures or substrates. Includes demolition operations.

Renovation - Altering, in any way other than demolition, one or more structural components of a building.

Repair - The restoration of asbestos containing insulation that has been damaged. It is usually located on pipes, boilers, tanks, turbines, ducts, or other facility components. Repair usually consists of the application of encapsulant, rewettable glass cloth, canvas, cement, or other suitable material to seal exposed areas where asbestos fibers may be released.

Respirable - Any particle small enough to reach the lungs when inhaled, i.e, breathable.

Respirator program - A written and implemented program established by an employer that provides for the safe use of respirators on their job sites.

Restricted use areas - Those areas of a building that have infrequent occupancy, such as unmanned boiler rooms, mechanical rooms, electrical rooms, and secured storage rooms; unless those areas supply ventilation air to the other parts of the building, in which case they would be classed according to the areas served by the ventilation air.

Routes of entry - One of three ways a substance may enter the body. The three routes of entry are inhalation, ingestion, and absorption.

RPA - Respirator program administrator

S

SAR - Supplied air respirator

Scanning electron microscopy - A method of microscopic analysis that uses an electron beam directed at the sample and then collects the electrons that are reflected to produce an image from which fibers may be identified and counted.

SCBA - Self-contained breathing apparatus

Self-contained breathing apparatus - A type of atmosphere supplying respirator that provides the highest degree of protection. Tanks of compressed grade "D" breathing air are worn on the back and supply the respirator.

Serpentine asbestos - A form of asbestos characterized by long, flexible, finely polished strands that can be woven into cloth.

Short-term exposure limit - The maximum concentration level of a hazard to which workers can be exposed for a short period of time (usually 10 to 15 minutes) without suffering adverse health effects.

Shower room - A room between the clean room and the equipment room in the worker decontamination enclosure with hot and cold or warm running water controllable at the tap and suitably arranged for complete showering during decontamination.

Single use respirators - Commonly known as disposable dust masks. This type of respirator offers absolutely no protection and are not acceptable when working with asbestos.

SM - Surfacing material

Sorbent - Granular material in a respirator cartridge or canister that absorbs specific contaminants from the air as the air is inhaled.

Spot repair - Any removal, repair, encapsulation, enclosure or other disturbance which encompasses: (1) up to 10 linear feet of asbestos from piping and/or (2) up to 25 square feet of asbestos from any surfaces other than pipes. Large projects divided into smaller segments are not spot repairs.

SS&HO - Site safety and health officer

STAA - Surface Transportation Assistance Act

Static sampling - Monitoring an area as it is without creating any additional disturbance in the air. Static sampling is typically used during the removal phase of the abatement project.

STEL - Short-term exposure limit

Substitution - A control measure in which a hazardous chemical is replaced by a nonhazardous or less hazardous chemical.

Substrate - The material to which the asbestos was originally applied, such as a concrete wall or ceiling. The substrate may be smooth, rough, pitted, etc., depending on the material.

Supplied air respirator - An atmosphere supplying respirator. Grade "D" breathable air is delivered to the worker at the proper pressure through a flexible hose or trunk line. The delivery system has the option of three regulator valves: continuous flow, pressure demand, or demand.

Surfacing ACM - Any surfacing material that contains more than 1% asbestos.

Surfacing material - Material that is sprayed, troweled-on, or otherwise applied to surfaces. Examples include acoustical plaster on ceilings; fireproofing materials on structural members; and other materials on surfaces for acoustical, fireproofing, and other purposes.

Surfactant - A chemical wetting agent added to water to improve its ability to penetrate asbestos-containing materials.

Synergism - A process in which two or more agents produce an effect that is greater than the sum of their effects together.

T

TC - Testified and certified

TEM - Transmission electron microscopy

Tensile - Having the ability to be stretched or extended.

Tested and certified - The approval of filter cartridges by NIOSH for a specific application.

Thermal system insulation - ACM supplied to pipes, fittings, boilers, breeching, tanks, ducts, or other structural components to prevent heat loss or gain.

Thermal system insulation ACM -Thermal system insulation that contains more than 1% asbestos.

Threshold limit value - Levels of contaminants established by the American Conference of Governmental Industrial Hygienists to which it is believed that workers can be exposed to with minimal adverse health effects.

Time weighted average - The average concentration of a substance in an area over an 8-hour work shift of a 40-hour work week.

TLV - Threshold limit value

Toxic - A substance that has an adverse effect on one's health.

Transmission electron microscopy - A method of microscopic analysis that uses an electron beam that is focused onto a thin sample. As the beam penetrates (transmits) through the sample, the difference in densities produces an image on a fluorescent screen from which samples can be identified and counted.

Tremolite - One of six types of asbestos. Tremolite is a more brittle asbestos and was not normally used commercially. It was most often found as a contaminant of chrysotile deposits and talc.

TSI - Thermal system insulation

TWA - Time weighted average

Type C supplied air respirator - A respirator that supplies air to the wearer from an outside source, such as a compressor.

Tyvek®- A durable paper material used in the manufacture of disposable protective clothing, such as the coveralls used in asbestos abatement.

U

UFL - Upper flammable limit

USEPA- United States Environmental Protection Agency

V

No entries

W

Wetting agent - A combination of chemicals that helps water soak into ACM. EPA recommends a wetting agent consisting of 50% polyoxyethylene ester and 50% polyoxyethylene ether in a ratio of 1 ounce to 5 gallons of water.

X–Z

No entries