

5 pages

DEPARTMENT OF LABOR GENERAL INDUSTRY SAFETY STANDARDS COMMISSION SAFETY STANDARDS

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(By authority conferred on the general industry safety standards commission by sections 16 and 21 of Act No. 154 of the Public Acts of 1974, as amended, being §§408.1016 and 408.1021 of the Michigan Compiled Laws)

R 408.10015 of the Michigan Administrative Code, appearing on page 444 of the 1978 Annual Supplement to the Code is amended, and R 408.10018 and R 408.10098 are added, to read as follows:

PART 1. GENERAL RULES

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ST0085610

GENERAL PROVISIONS

R 408.10001. Scope.

Rule 1. This part sets forth general rules for the employer and the employee in, around and about a place of employment, except that where a specific rule is set forth in another standard, the general rule is preempted.

R 408.10003. Definitions: A to M

Rule 3. (1) "Aisle" means a designated path of travel for mobile equipment and employees.

(2) "Approved" means approval by the director of labor or his duly designated representative.

(3) "Confined space" means an enclosed space, such as, but not limited to, a bin, furnace, cupola, tank, vessel, vault, or well.

(4) "Equivalent" means an alternate design or feature which provided at least as effective or greater degree of safety.

(5) "Explosive atmosphere" means an atmosphere in which the contaminants are within the minimum and maximum range in air, oxygen or other oxidizer which would explode on introduction of a source of ignition.

(6) "Flammable" means to ignite easily, burn intensely, or to have a rapid rate of flame spread.

(7) "Hazard" means an unsafe condition or procedure which could result in an injury.

(8) "Machine" means a powered instrument or device which transmits force or motion in a predetermined manner. It may be fixed in place or transportable but is not hand held.

R 408.10004. Definitions P.

Rule 4. (1) "Passageway" means a path of travel for an employee only.

(2) "Pinch point" means a point at which it is possible to be caught between the moving parts of a machine, or between the moving and stationary parts of a machine or between material and any part of a machine.

(3) "Point of operation" means the point on a machine where work is performed.

(4) "Power failure" means the loss of power from the energy sources.

(5) "Power source" means the energy supplied by hydraulic, pneumatic, electrical or other source.

PART III - CONTROL MEASURES FOR HAZARDOUS ATMOSPHERES
(INCLUDING TANK AND VESSEL ENTRY)

Rule 3301 Control Methods for Process Spaces Containing a Known or Suspected Non-respirable Atmosphere

(1) Definitions, as used in this rule:

(a) "Atmosphere immediately dangerous to life or health" means a non-respirable atmosphere. [R 325.2405(a)]

(b) "Non-respirable atmosphere" means an atmosphere which contains insufficient oxygen, or an elevated level of contaminants which may render a person incapable of self-rescue. [R 325.2403(d)]

(c) "Process space" means a tunnel, process equipment, shaft or enclosed space. [R 325.2410(f)]

(2) General

(a) Before an unprotected person enters a process space, the atmosphere shall be thoroughly ventilated and tested to determine the presence of a respirable atmosphere. Precautions shall be taken to prevent the creation of non-respirable atmosphere in the process space during the time that a person is inside. [R 325.2430(1)]

(b) In the absence of ventilation or tests, or if a test shows the presence of a non-respirable atmosphere, a person trained in the use of protective equipment shall be provided with an approved supplied-air respirator or self-contained breathing apparatus, safety harness and lifeline before entering the process space. Persons, capable, trained and equipped to perform rescue shall be stationed outside the process space to maintain surveillance over the person entering. [R 325.2430(2)]

Rule 3302 Use of Respirators in Dangerous Atmospheres - General

Written procedures shall be prepared covering safe use of respirators in dangerous atmospheres that might be encountered in normal operations or in emergencies. Personnel shall be familiar with these procedures and the available respirators. [1910.134(a)(3)]

(1) In areas where the wearer, with failure of the respirator, could be overcome by a toxic or oxygen-deficient atmosphere, at least one additional man shall be present. Communications (visual, voice, or signal line) shall be maintained between both or all individuals present. Planning shall be such that one individual will be unaffected by any likely incident and have the proper rescue equipment to be able to assist the other(s) in case of emergency. [1910.134(e)(3)(1)]

(2) When self-contained breathing apparatus or hose masks with blowers are used in atmospheres immediately dangerous to life or health, standby men must be present with suitable rescue equipment. [1910.134(e)(3)(11)]

CHAPTER III - HEALTH HAZARD CONTROL MEASURES

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(2) When self-contained breathing apparatus or hose masks with blowers are used in atmospheres immediately dangerous to life or health, standby men must be present with suitable rescue equipment. [1910.134(e)(3)(ii)]

ST0085608

CARBON MONOXIDE POISONING

Symptoms

- o Dizziness, nausea, headache, drowsiness, vomiting, collapse, coma, & death (note similarity of symptoms to heat stroke)

Sources

- o Oil Lubricated Compressor
- o Internal Combustion Engine
- o Open Flame & Fire
- o Unvented Gas
- o Kerosene Heaters

Description of CO: o Colorless, Odorless & Tasteless

Limits:

- o 50 ppm (Time Weighted Average over 8 hours)
- o 500 ppm (Short Term Exposure Limit - 15 minutes)
- o 20 ppm (Grade D breathing air for airline respirators) (Maximum allowable concentration)

If these symptoms are observed, those persons should immediately be brought into fresh air and medical attention should be provided.

Monitor any prescription or over the counter medicines being used by employees. These may cause an adverse reaction when used by persons under strenuous conditions common to removal work.

ST0085607

HEAT STROKE

Symptoms:

- o Dizziness, nausea, severe headache, hot dry skin, confusion, collapse, delerium, coma, & death

Treatment:

- o MEDICAL EMERGENCY
- o Remove worker from hot area
- o Remove clothing
- o Have them lay down
- o COOL THE BODY (SHOWER, COOL WET CLOTHS)
- o Do Not give stimulants

Causes:

- o High air temperature
- o High humidity
- o Low air movement
- o Hard work
- o Not enough breaks away from the heat
- o Not drinking enough water
- o Full body clothing
- o Workers not acclimated to heat

Telephone numbers of the physicians, hospitals, and ambulances should be conspicuously posted for emergency use.

Means should be available for prompt transport of an injured person to a physician or hospital, and there should be a telephone with emergency numbers available.

Before beginning the project, provisions should be made for prompt medical attention in case of serious injury or other medical emergency.

Someone trained in basic first-aid should always be on the abatement project.

When airline respiratory protection is used, it is important that the outside monitor be familiar with the system and any problems associated with breathing air. Carbon monoxide poisoning is perhaps the most important of these problems. It is important to note that these symptoms are similar and may be confused with those from heat stress.

ST0085606

MEDICAL SERVICES AND FIRST AID

The OSHA Asbestos Standard for the construction industry requires that all employees who are exposed to asbestos at or above the action level or who are required to wear a negative pressure respirator be given a complete physical examination. The main objective of the examination is to determine that the employee is medically qualified to wear a respirator before performing abatement activities. The examining physician or clinic should be aware that respirators may be worn under hot, adverse conditions. During warm months, heat exhaustion and heat stroke are serious hazards faced by workers, particularly those not acclimated to the heat.

Heat-Related Disorders

It is important for the employer to provide training in recognition and awareness of the symptoms and effects of heat stress and heat stroke. It is also important to stress the importance of drinking water and maintaining proper electrolyte levels.

HEAT EXHAUSTION

Symptoms:

- o Fatigue, weakness, profuse sweating, normal temperature, pale clammy skin, headache, cramps, vomiting, fainting.

Treatment:

- o MEDICAL ALERT
- o Remove worker from hot area.
- o Have worker lay down and raise feet
- o Apply cool wet cloths
- o Loosen or remove clothing
- o Allow small sips of water or Gatorade if victim is not vomiting

Prevention:

- o Frequent breaks away from the heat
- o Increase fluid intake
- o Allow workers to become acclimatized to heat.
- o External cooling (vortex cooling, ice vests)

Causes:

- o High air temperature
- o High humidity
- o Low air movement
- o Hard work
- o Not enough breaks away from the heat
- o Insufficient fluid intake
- o Full body clothing
- o Workers not acclimated to heat

ST0085605

EMERGENCY PROCEDURES

Effective December 11, 1980, the Occupational Safety and Health Administration revised its fire safety standards. OSHA now requires a written emergency action plan and fire prevention plan. The new requirements are detailed in 29 CFR 1910.38. Briefly, the essential items of the plans should include:

- o The manner in which emergencies are announced.
- o Emergency escape procedures and emergency escape routes.
- o Procedures for employees who must remain to operate critical plant operations which may take time to shut down.
- o Procedures to account for all employees after evacuation.
- o Rescue and medical duties.
- o Names and/or job titles of people to be contacted for additional information.
- o A list of the major workplace fire hazards.
- o Names and/or job titles of people responsible for maintenance of fire prevention equipment.
- o Names and/or job titles of people responsible for the control of fuel source hazards.

Establish a system for alerting workers of an emergency or other problem that may require evacuation of the work area. A compressed air boat horn provides an effective alarm that can be heard and does not rely on a power source. All persons entering the work area should be familiar with the evacuation alarm signal and primary and secondary exits. A simple floor plan drawing of the work area should be posted to familiarize persons entering the work area with the site and location of exits (see FIGURE XII - 3).

Written emergency procedures should cover procedures to be used in case of the following: fire, which may include heavy smoke conditions; power failure; compressor failure with the use of air-supplied respirators; accident; or employee injury.

ST0085604

- o When using a cutting torch, know what is on the other side of the wall and below the floor. Use sheet metal or a treated tarp to catch sparks.
- o Reduce the amount of flammable/combustible materials inside a space to a minimum prior to hanging plastic. This includes removal of any chemicals, flammable liquids, heat sensitive materials, etc.
- o Mark exits from work area and post directional arrows when exits are not visible from remote work areas. This can easily be done using duct tape on the polyethylene walls and barriers. It is recommended that these directional arrows be placed close to the ground to assist workers who may be crawling in smokey conditions to escape a fire.
- o Keep trash and debris to a minimum (i.e., tape, poly, bags, lumber, etc.).
- o If the work area is large and many workers are present, several emergency exits may be needed. Choose exits that are locked from outside but can be opened from the inside. A daily inspection should be conducted to insure secondary exits are not blocked.
- o Lighting of exits and exit routes should be provided.
- o In case of fire, the fire hazard becomes more immediate than the asbestos hazard and workers may need to violate the plastic barriers. This should be covered with workers in the emergency action plan for the job site.
- o Be alert for flammable vapors in industrial areas (solvents such as naphtha, toluene, xylol, etc.). This is especially critical in industrial vacuuming operations where vacuum motors are not explosion proof. Compressed air vacuums may be required.
- o A telephone should be available at all times for notification of authorities in an emergency.
- o Post local Fire Department and Rescue Squad phone numbers. Advise them of the operations in progress.
- o Ensure that you have a monitor outside at all times trained in emergency procedures. Someone should be trained in first aid, and in the treatment of heat stress.

FIRE CONSIDERATIONS

Fires can create immediate life threatening conditions. Fire prevention/control should be given a high priority both during planning and removal stages of asbestos projects. A few of the fire safety features to be concerned with are exits, travel distances, emergency lighting, and alarm systems.

Sealing off an area and blocking entrance/exit openings conflict with OSHA, NFPA, and local fire code requirements. The contract specifications may state "one means of egress through a properly designed decontamination system"; however, emergency plans should be developed to include alternative exits in emergency situations and these must be familiar to all personnel entering the work area.

Perform a pre-work survey to determine potential fire hazards, sources of ignition, hot-spots, and location of exits. Coordinate this with the number of workers to be in the area, the square footage, and the types and amount of combustible/flam-mable materials that will remain on site.

Some protective clothing will burn and melt quickly. It can shrink, adhere to skin and drip as it burns. Heavy black smoke is a combustion by-product.

Polyethylene (it's combustible) will start to burn slowly and pick up speed as more heat is generated. It gives off heavy smoke as the fire progresses. Flame spread is slow and steady. Poly also produces toxic gases during thermal decomposition. Workers would not be adequately protected from smoke with respirators used for asbestos work. Sheeting should be kept away from heat sources such as transformers, steam pipes, boilers, etc., that will be heated during removal. (Polyethylene should not be allowed to contact surfaces above 150°F.)

To Avoid Fire Problems in Asbestos Control Areas:

- o 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, compressors, etc., are extinguished.
- o Locate "hot spots." Quite often you will have to drape equipment instead of sealing off to prevent overheating (i.e., computers, terminal boards, switch panels, transformers).
- o Cut off supply to steam lines, electric and steam heaters, and radiators. Do not permit the polyethylene to lay against hot surfaces.
- o Do not allow lighters, matches, etc., into the work area. Strictly enforce no smoking, eating, or drinking inside the work area.
- o When using an oxygen/acetylene torch to cut pipe, etc., post a fire watch with an appropriate fire extinguisher such as pressurized water. Do not use CO₂ extinguishers in confined or enclosed spaces. Dry chemical extinguishers are effective, but the powder is a respiratory irritant.

ST0085602

Slips, Trips, and Falls

Areas sealed with polyethylene and kept damp to reduce airborne fibers become very slick. Disposable booties are a potential trip hazard; air and electrical lines also create trip 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. The National Safety Council estimates that there are 200,000 to 300,000 disabling injuries in work related falls each year. Over 40 percent of the workers were employed in the construction industry.

To Summarize:

- o Consider the height of the work, equipment in use, and numerous trip hazards. Take a look at your "walking surfaces".
- o 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 non-skid soles may be an alternative depending on the job.
- o Inspect ladders and scaffolding for condition. Ensure railings are adequate on scaffolds.
- o Minimize water on floors. Wet polyethylene is very slick and water increases the risk of electrical shock.
- o Use care around air lines and electrical cords. —
- o Suspend electrical lines and cords when possible using tape.
- o No running, jumping or horseplay in work areas should ever be allowed.
- o Minimize debris on floors.
- o Pick up tools, scrapers, etc.

ST0085601

SCAFFOLD UPSET FORMULA

$$(B)(f) = (W)(A)$$

Where:

(B) = height from floor to ceiling

(f) = force required to upset scaffold

(W) = weight of scaffold and worker

(A) = $\frac{1}{2}$ width of scaffold

Example:

(B) = 14'

(f) = x

(W) = 374 lbs.

199 lb scaffold
175 lb man

(A) = 1'

Force to upset: 26.7 lbs.

$$14 (x) = 374 \times 1$$

$$(x) = \frac{374 \times 1}{14}$$

$$(x) = 26.7 \text{ lbs.}$$

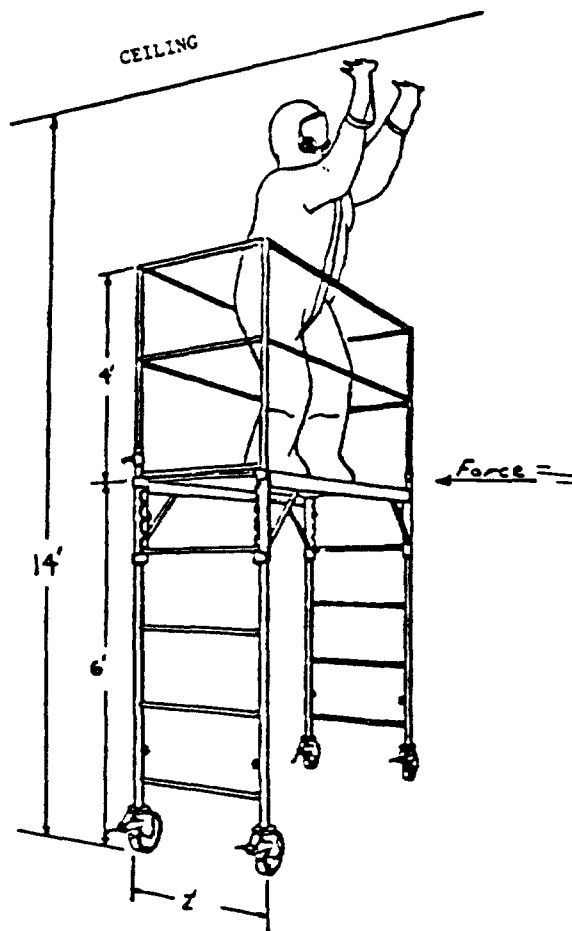


FIGURE XII - 2

(NOTE: This formula is an estimate way to obtain a reasonable idea of the force needed to upset scaffolding. Many variables need to be considered in addition to those illustrated.)

ST0085600

Scaffolding

Most asbestos abatement projects will involve the use of scaffolding. Proper set up, regular inspection, and basic maintenance should not be overlooked. In many removal projects, manually propelled mobile scaffolding provides a convenient and efficient work platform. OSHA standards require that when free standing mobile scaffolding is used, the height shall not exceed four times the minimum base dimension. This requirement is based on the fact that scaffolding is easily turned over. Figure XII - 2 illustrates a simple method to estimate a reasonable amount of force necessary to tip a scaffold. Since relatively little force is required to tip a scaffold, it becomes important to make sure that wheels on mobile scaffolds move freely and are in good repair. If rented scaffolding is used, all components should be inspected prior to accepting it. Wheels should turn freely and be lubricated. All components such as cross bracing, railings, pin connectors, planking or scaffold grade lumber should be available before the units are assembled. When workers will be riding mobile scaffolding the base dimension should be at least one half of the height. Workers should be careful to keep debris bagged and obstacles off the floor where mobile scaffolds will be used. If a wheel catches debris on the floor when the unit is moved, additional force will be required to move it. This additional force may be all that is needed to turn the unit over.

Guardrails should always be installed on scaffolding used for abatement projects. Workers are usually looking up while working and can easily step off the edge of an unprotected scaffold. OSHA requires that guardrails be used when scaffolding is from 4 to 10 feet tall and less than 45 inches wide. Scaffolding 10 feet or higher must have guardrails.

Planking used on a scaffold should not extend farther than 12" over the edges and should always be secured to the frame.

ST0085599

**LADDERS/SCAFFOLDING/WALKING - WORKING SURFACES
(INSPECTIONS AND PROPER USE)**

LADDERS AND SCAFFOLDS

Asbestos abatement projects always present risks to workers from falls, slips, or trips. The nature of the tasks necessitate the use of scaffolding and ladders.

Ladders

The following items should be checked on a regular basis:

- o Ladders are always maintained in good condition.
- o Complete inspections are done periodically.
- o No improvised repairs are made.
- o Defective ladders are not used.
- o Safety feet spreaders and other components of ladders are in good condition. (Missing safety feet create sharp edges that will cut polyethylene floor covers.)
- o Movable parts operate freely without binding or undue play.
- o Rungs are kept free of grease or oil.
- o Ladders are not used for other than their intended purpose. (Ladders should not be used as a platform or walkboard.)
- o Extension type ladders should be used with a 1-4 lean ratio (1 foot out for every 4 feet of elevation).
- o Step ladders should only be used when fully opened.
- o The user faces the ladder while going up and down.
- o Tops are not used as steps. If needed, get a longer ladder.
- o Bracing on the back legs is not used for climbing.
- o Portable ladders are used by one person at a time.
- o Ladders are secured to prevent displacement during use.
- o All ladders have well designed safety shoes.
- o Hook or other type ladders used in structures are positively secured.
- o Wood or fiberglass ladders should be selected to avoid electrical hazards of metal ladders.

ST0085598

- o Energized parts must be insulated or guarded from employee contact and any other conductive object.
- o Extension cords used with portable electric tools and appliances must be the three-wire grounded type and connected to a GFI (Ground Fault Interrupter) circuit.
- o Extension cords:
 - should be protected from accidental damage.
 - should not be fastened with staples, hung from nails, or suspended by wire (tape is an acceptable alternative).
- o Portable electric handtools should meet the following requirements:
 - Should be equipped with a 3-wire cord having a ground wire permanently fixed to the tool frame; or
 - Should be of double-insulated type and labeled as such.
- o For circuits over 600 volts, if electrical disconnects are not visible and open or locked out, the following requirements should be met:
 - Circuits to be de-energized are clearly identified and isolated from all energy sources.
 - Notification received from a designated employee that all switches and disconnectors that could supply energy have been de-energized, locked out, and plainly tagged to show men at work.
 - Visual inspections and tests made to assure de-energizing of lines and equipment.
 - Protective grounds applied to disconnected lines or equipment.
 - Separate tag and lockout attached for each crew requiring de-energizing of same line or equipment.
 - Tags and lockouts should not be removed from completed work until designated employees report that all crew members are clear and protective grounds they installed have been removed.

ST0085597

ELECTRICAL SAFETY REVIEW

- o The use of wet methods increases the potential for electrical shock when working around electrical panels, conduit, light fixtures, alarm systems, junction boxes, computers, transformers, etc.
- o De-energize as much equipment as possible. Use portable flood-light systems for lighting and regularly check the system and wiring for damage. Twelve volt lighting systems are available that work very well.
- o Consider using dry removal in areas immediately adjacent to energized electrical equipment if de-energizing is not feasible. Consultation with local NESHAP authorities is necessary to prevent citation for failure to use wet methods.
- o Use non-conductive scrapers and vacuum attachments (wood, plastic, rubber).
- o Supply workers with heavy insulated rubber boots and/or gloves when working around energized wiring or equipment (lighting, panel boxes, transformers).
- o Ensure all electrical equipment in use is properly grounded before the job starts. This means checking outlets, wiring, extension cords and power pickups. Check for the ground-pin on plugs. These checks should also be made while setting up and regularly during the job.
- o Use care not to violate insulated coverings with scrapers, scaffolding wheels, etc. Rolling a heavy cart or scaffold over a flexcord can easily cause internal damage.
- o Avoid stringing electrical wiring across floors. Elevate wiring if possible to keep it away from water on the floor and damage from foot traffic and rolling scaffolds. Duct tape is effective for this.
- o Do not allow water to accumulate in puddles on work area floors. NESHAP regulations require damp conditions, not standing water!
- o Ensure electrical outlets are tightly sealed and taped to avoid water spray.
- o Always perform a pre-work walk-through to identify potential sources of electrical hazards to abatement workers, or equipment that may be damaged by wet removal methods.
- o Use stable wooden or fiberglass ladders - not metal.
- o Determine operating voltages of equipment and lines before working on or near energized parts. De-energize and lock-out when possible.
- o Electrical equipment and lines should be considered energized unless tested and determined otherwise.

ST0005596

Ground-Fault Circuit Interrupter

GFCI monitors the difference in current flowing into the "hot" and out to the grounded neutral conductors. The difference ($\frac{1}{2}$ ampere in this case) will flow back through any available path, such as the equipment grounding conductor, and through a person holding the tool, if the person is in contact with a grounded object.

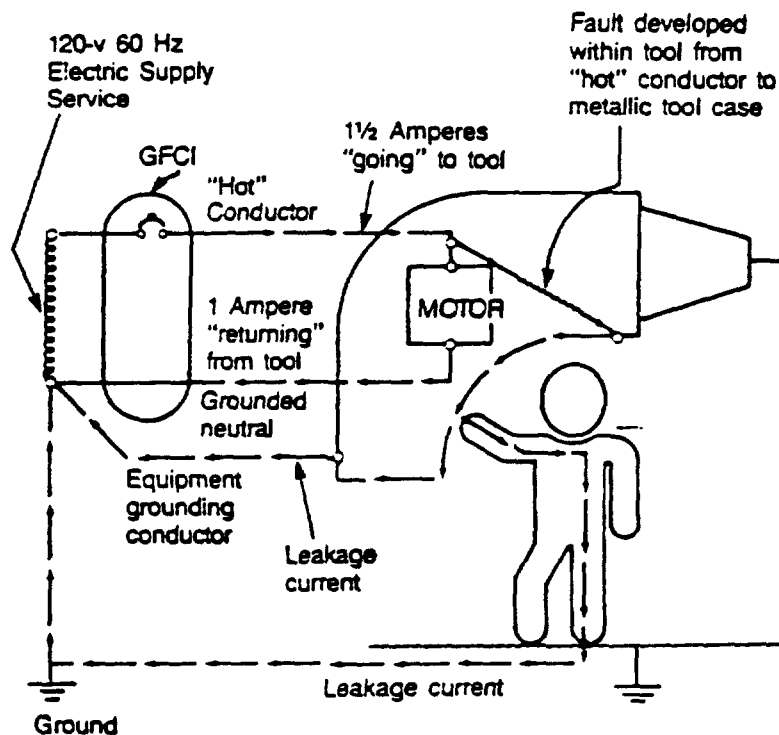


Figure XII - 1

located inside the removal area and that control other parts of the building must remain energized. Sealing transformers or control boxes may not be possible due to heat build-up. If this situation is encountered, polyethylene will have to be kept away to allow for air circulation and dry removal around them may be necessary to avoid a serious shock exposure. Where this situation is encountered, all breakers and switches should be clearly labeled in case power must be secured to other areas of the building during the removal project.

- o Providing power inside the removal area: This can create hazards not associated with the building systems. Since OSHA considers abatement projects under the 29 CFR 1926 Construction Industry Safety and Health Standards, there are special requirements for supplying temporary power. This may be done by supplying power through Ground Fault Circuit Interruptors (GFCI) or having an Assured Equipment Grounding Program in effect. Use of GFCIs to protect all circuits provides the safest power source since any significant current leakage will trip the circuit (see Fig. XII - 1). These devices prove most effective when kept outside the work area away from the high humidity. An assured equipment grounding program requires regular inspection of all tools, cords, and electrical devices with written documentation maintained.
- o Commonly found electrical devices on abatement projects are: Lights, HEPA vacuum cleaners, negative air systems, drills, saws, heaters, sump pumps, and often, radios. All of these should be inspected regularly for damage, proper grounding, and integrity of insulation.

With the above mentioned items in place, there are still several basic items that should not be overlooked. When possible, non-metallic tools should be used for scraping to prevent a possible shock if wiring is cut or contact is made with energized equipment. Insulating the handles of metal scrapers is another option. Hard rubber or plastic scrapers, while more difficult to find, perform well for removal. Wooden or fiberglass ladders reduce or eliminate a ground path if a worker contacts an energized circuit.

ST0085594

ELECTRICAL SAFETY CONSIDERATIONS

THE HAZARD

One of the most common hazards, and one that gives the least warning, is electrical current. Incorrect wiring, improper grounding, and lack of proper shielding results in approximately 1,000 people per year being electrocuted nationwide. Many of these fatalities result from contact with only 120 volts a.c.

Three factors determine the severity of electrical shock. These are:

- o The amount of current flowing through the body
- o The path of the current flowing through the body
- o The time the current is allowed to follow this path

These factors vary greatly. The path of the current depends upon the points of contact. Most often the path is from the hands, through the body, and out the feet. The amount of electrical resistance determines in part the amount of current flow. Moist skin or damp conditions greatly reduce electrical resistance and significantly increase a person's risk of serious injury if he comes in contact with a current source. In addition to the obvious shock potential, many deaths result from falls after a non-fatal electrical shock.

Pre-Work Considerations/Identifying The Hazards

During the pre-bid inspection, preparation of the work site, and during asbestos removal, there are potential electrical hazards that can be identified and eliminated. Examples include:

- o Identification of wiring faults in the building: Including open ground paths, reverse wiring polarity, and hot-neutral or hot-ground wires reversed. These common faults can easily be identified with a volt/ohm meter or with plug-in type circuit testers and should be corrected prior to the start up. This is particularly important if these circuits will be used to provide power inside the removal area.
- o Uninsulated or exposed and energized wiring or equipment: Asbestos removal jobs are often part of renovation or remodeling projects. Overhead lighting is often removed for cleaning. Equipment or machinery may have been moved out of the area during the removal job and wiring left in place. Damaged equipment or electrical fixtures may not have not been repaired by the building owner. All of these things may be combined to create sources of contact with energized electrical circuits. When possible, circuits that will not be used during removal efforts should be turned-off and locked out. Wiring and electrical connections should always be considered energized until tested and proven otherwise. Unenclosed wiring junctions in overhead areas are a particularly likely point of contact for removal workers.
- o Asbestos abatement projects where the building remains occupied: This is becoming more common as industrial and commercial projects are increasing. This can present problems where electrical circuits or control panels that are

ST0085593

SAFETY AND HEALTH CONSIDERATIONS

INTRODUCTION

Asbestos abatement projects have become increasingly technically sophisticated as the body of knowledge grows regarding effective control methods. A great deal of attention has been given to protecting workers and confining fibers. The extra burden of dealing with the asbestos hazard can easily create situations where the basic and more immediate safety hazards can be overlooked.

Safety hazards can manifest if good work practices are not followed. Potential hazards include: electrical considerations, ladders and scaffolding, working surfaces, fire consideration, heat related disorders and body protection. The methods used in a typical abatement project (sealing the work area, using wet methods, working at heights on ladders and scaffolding, and shutting down normal building systems) add new dimensions to the task of providing a safe working environment.

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different forms of asbestos will react differently to the application of water. For example, chrysotile will typically accept water, while amosite is generally more resistant to wetting. Therefore, employees will have to take appropriate protective measures since airborne fiber concentrations will be potentially higher when a removal job involves amosite. Employees should be instructed in methods of misting the air with water, and also in the proper methods of using the HEPA vacuum. Additionally, the function of negative air units should be outlined and employees made aware of the need to ensure that these units are kept running so that if a rupture occurred in the enclosure, fiber leakage would be minimized.

A very important aspect of employee training that is often taken lightly is the recognition and control of safety and health hazards (other than asbestos) in an asbestos abatement work area. Proper training can help reduce employee injuries, and lost time accidents. Subject areas that should be covered in this part of the session include the proper use of scaffolding, how to recognize and/or eliminate trip/slip hazards, the proper use of ladders, the identification of any electrical hazards, and how to avoid heat stress/heat stroke situations.

The next phase of employee training should entail cleaning up the work area. This cleaning will take place after gross removal has occurred and all residual debris is ready to be disposed of. Wet cleaning techniques should be reviewed (wetting the waste and collecting it off the floor). Settling times should also be discussed.

Correct disposal of asbestos-containing debris is also an important aspect of an abatement employee training program (specifically for employees that will be directly involved with disposal operations). This part of the program should include discussions on the need to place the wetted waste in appropriately labeled six mil polyethylene bags. These bags should then be placed in airtight fiberboard drums before being loaded into the enclosed truck to be taken to the landfill. (Note: See section entitled, "Waste Disposal Requirements.") It is important that any employees who might be involved with this type of operation in some way be made aware of the proper procedures for carrying out these waste disposal activities and the protective equipment required.

Another important aspect that an employee training program should include is information on final inspections/air sampling, and why it is important. The reason that employees need to be aware of what the final inspections will entail is because when they finish work in a certain area, they can conduct a fairly thorough visual inspection themselves.

Employees should also be informed as to why air sampling is being conducted and what the results mean. Employees should be informed that they may be asked to wear a personal air sampling pump while they are performing their job so that the fiber levels they are exposed to can be closely monitored. They should be requested to cooperate with the industrial hygienist when it is their turn to wear the sampling equipment. It must also be emphasized to the employees not to tamper with the sampling equipment they are wearing since the results will indicate the level of airborne fibers to which they are being exposed.

One area that the training program should cover is an explanation of the personnel decontamination sequence. This should cover procedures to be followed when beginning or finishing a shift of asbestos abatement work. When beginning a shift,

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medical hazards associated with breathing asbestos should give this part of the training session. It is important that not only the health hazards be discussed, but also how the fibers enter the body, and what happens once they are contained inside the lungs. Fiber size, visibility, and settling times are all important information. A film or slides may be helpful in illustrating these points.

After employees are made aware of the health hazards associated with asbestos exposure, the next phase of training should be on what they can do to protect themselves from this exposure (i.e., work practices and personal protective equipment). This training should include step-by-step instruction on how to perform each task associated with their jobs (i.e., glovebagging, wetting and scraping, etc.). Also, training should include a comprehensive review of the use of respiratory protection, including the following aspects:

- a. How to put on and take off the respirator
- b. Cleaning and maintaining of respirators
- c. Inspection of respirators
- d. Fit testing of respirators
- e. Discussion on uses and limitations of different types of respirators
- f. Hands-on experience (look at various parts)

Note: The training requirements of an effective respiratory protection program are addressed in the section entitled, "Respiratory Protection."

It is also important that workers be properly trained in the use of protective clothing. They should be made aware of its limitations, and how it should be used to optimize the protection factor. (Note: See section entitled "Worker Protection".)

The next phase of the training program should be a discussion of all applicable EPA and OSHA regulations regarding asbestos abatement projects. Also, there may be certain state or local regulations of which employees need to be aware. This part of the program should not be extremely detailed, rather it should provide the employees with a good understanding of what they should or should not do when conducting removal of asbestos-containing materials. It should be emphasized that the main concern is the safety and health of the workers, rather than simply the concern of receiving a citation for a violation.

The fifth phase of employee training should deal with proper techniques for sealing off the work area. In this section, employees will be instructed on what to look for before sealing off the work area and also how to construct a safe and effective enclosure. Employees should first be made aware of what an HVAC system is and how it affects the air movement through an area. They should also be instructed on how to shut down the system and seal off outlets and inlets so that airborne fibers will not be drawn into it. Employees should then be instructed in proper techniques for erecting plastic barriers, draping the walls, floors, and furniture with six mil polyethylene. This also includes construction of airlocks and change rooms, in addition to posting appropriate warning signs, etc. Also, it is important to inform employees that if a puncture develops in the polyethylene enclosure while the work area is active, they should stop work and immediately seal the leak.

Following the session on sealing off the work area, workers should be trained in how to effectively confine and minimize airborne fiber generation. This can best be accomplished through proper use of wet methods (i.e., spray the asbestos-containing material with amended water). Workers should also be informed at this time that

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16. The insulation can now be lifted off the pipe and gently placed in the bottom of the bag.
17. Using the scrub brush, rags and water, scrub and wipe down the exposed pipe inside the glovebag. (Note: Inexpensive horse rub-down mittens work well for this.)
18. Wet the donut-shaped pieces of wettable cloth over the exposed ends of insulation remaining on the pipe. Wettable cloth is a plaster impregnated fiberglass webbing available at many hardware and/or plumbing supply stores.
19. Remove the water wand from the water porthole and attach the small nozzle from the HEPA-filtered vacuum. Turn on the vacuum only briefly to collapse the bag.
20. Remove the vacuum nozzle and twist the water porthole closed and seal with duct tape.
21. From outside the bag, pull the tools through the glove and away from the bag and twist it to separate it from the bag. Place duct tape over the twisted portion and then cut the glove from the glovebag, cutting through the twisted/taped section. In this manner, the contaminated tools may be placed directly into the next glovebag without cleaning. Alternatively, the glove with the tools can be placed in a bucket of water, opened underwater, and the tools cleaned and dried without releasing asbestos into the air. (Note: Rags and the scrub brush cannot be cleaned in this manner and should be discarded with the asbestos waste.)
22. With the removed insulation in the bottom of the bag, twist the bag several times and tape it to keep the material in the bottom during removal of the glovebag from the pipe. (A HEPA vacuum may help suction air out of the glovebag.)
23. Slip a 6 mil disposal bag over the glovebag (still attached to the pipe). Remove the tape and open the top of the glovebag and fold it down into the disposal bag.
24. Remove the disposable suits and place these into the bag with the waste.
25. Twist the top of the bag closed, fold this over ("gooseneck" style), and seal with duct tape. Ensure that the outermost bag is appropriately labeled per OSHA, EPA and DOT regulations.
26. Using a clean damp rag, wipe the exterior of the respirator and leave the work area. Remove the respirator.
27. Asbestos-containing material must be disposed of at an approved landfill in accordance with EPA regulations.
28. Air sampling should be conducted during and after completion of glovebag projects to determine if undetected leakage occurred. Sampling should be done by qualified persons. Once a good visual inspection has been conducted, it will be possible for re-entry by unprotected personnel. Reinsulation may also occur at this point. For further information concerning sampling procedures and clearance criteria, see the section entitled, "Air Sampling Requirements."

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6. Place the necessary tools into the pouch located inside the glovebag. This will usually include the flexi-saw, utility knife, rags, scrub brush, wire cutters, tin snips and wettable cloth. Note: It may be easiest to pre-cut the wettable cloth at this point. Cut out a donut shape with the inner diameter 1/2-inch smaller than the diameter of the pipe beneath the insulation. The outer diameter of the donut should be three inches longer than the diameter of the pipe insulation being removed. Finally, cut a slit in each of the two donuts so they can be slipped around the pipe. (Putting the wettable cloth in a small air-tight ziploc bag may make it easier to handle.)
7. Place one strip of duct tape along the edge of the open top slit of the glovebag for reinforcement.
8. Place the glovebag around the section of pipe to be worked on. If the bag has double sided tape at the top, a preliminary seal can be made at this point. Next, fold the flap back and tape it down with a strip of duct tape. This should provide an adequate seal along the top. Next, duct tape the ends of the glovebag to the pipe itself, previously covered with plastic or duct tape.
9. Using the smoke tube and aspirator bulb, place the tube into the water porthole (two-inch opening to glovebag). By squeezing the bulb, fill the bag with visible smoke. Remove the smoke tube and twist the water porthole closed. While holding the water porthole tightly, gently squeeze the glovebag and look for smoke leaking out, especially at the top and ends of the glovebag. If leaks are found, they should be taped closed using duct tape and the bag should be re-tested with smoke.
10. Insert the wand from the water sprayer through the water porthole. Using duct tape, tape the water porthole tightly around the wand to prevent air leakage.
11. One person places his hands into the long-sleeved gloves while the second person directs the water spray at the work.
12. If the section of pipe is covered with an aluminum jacket, this is removed first using the wire cutters to cut any bands and the tin snips to remove the aluminum. It is important to fold the sharp edges in to prevent cutting the bag when it is placed in the bottom. Use caution to prevent cuts - these edges are sharp!
13. With the insulation exposed, use the flexi-saw to cut the insulation at each end of the section to be removed inside the glovebag. (Note: A flexi-saw is a serrated heavy-gauge wire with ring-type handles at each end.) Throughout this process, water is sprayed on the cutting area to keep dust to a minimum.
14. Once the ends are cut, the section of insulation should be slit from end to end using the utility knife. The cut should be made along the top of the pipe and water continuously supplied. Again, care should be taken when using the knife not to puncture the bag. Some insulation may have wire to be clipped as well.
15. Spray all tools with water inside the bag and place back into pouch.

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BEFORE STARTING THE PROJECT

Two persons are typically required to perform a glovebag removal project. A third person is often available to assist with supplies, keep unwanted visitors out of area, and possibly to conduct the air monitoring. Each of these team members should have received training on the use and limitations of glovebag removal projects. They should also be included in the respiratory protection program and medical surveillance programs.

Before any work begins, all necessary materials and supplies should be brought into the work area. This work area should be roped off and danger signs posted on the perimeter to minimize the chance of visitors entering this area. Barrier tape (3-inch) with a preprinted asbestos warning works well for this purpose. The HVAC system serving the work area should be shut down, if possible. Employees should be trained in emergency procedures in the event the glovebag ruptures. These emergency procedures usually include wet cleaning and/or HEPA vacuuming procedures and a shower available at a remote location. With this phase completed, the following generic guidelines may be used for most pipe lagging projects. It is important to not attempt to conduct glovebag removal on hot pipes (over 120°F) due to the possibility of the bags melting over the worker's hands and arms. Some manufacturers are currently experimenting with the development of special "high temperature" glovebags to allow removal from hot surfaces; however, it is still necessary to exercise extreme caution when dealing with these types of situations. (Polyethylene will melt at 150°F.)

REMOVAL PROCEDURES

1. Following the manufacturer's directions, mix the surfactant with water in the garden sprayer.
2. Have each employee put on a high efficiency cartridge respirator approved for use against asbestos and check the face-fit.
3. Have each employee put on a disposable full-body suit. Remember, the hood goes over the respirator straps.
4. Check the pipe where the work will be performed. If it is damaged (broken lagging, hanging, etc.), wrap the entire length of the pipe in polyethylene plastic and "candystripe" it with duct tape. A common error when doing glovebag work is forgetting that loose pipe lagging several feet or even several yards away from the glovebag work may be jarred loose by the removal activity. This is one of the common causes of high airborne fiber concentrations during glovebag work. Another problem is failure to clean up debris on the floor and other surfaces which has accumulated and contains asbestos. If the pipe is undamaged it is still necessary to place one layer of duct tape around the pipe at each location where the glovebag will be attached. This serves two purposes. First, it gives a good surface on which to seal the ends of the glovebag. Second, it minimizes the chance of releasing fibers when the tape at the ends of the glovebag is peeled off at the completion of the job.
5. Open the top of the glovebag and cut down the sides to accommodate the size of the pipe (about two inches longer than the pipe diameter). Some bags have zippers or two-sided tape on top and straps at each end facilitating easier installation of the bag on the pipe.

OVERVIEW OF GLOVEBAGS AND THE GLOVEBAG PROCEDURE

A glovebag typically consists of a three to twelve mil polyethylene or polyvinyl chloride (PVC) bag fitted with long sleeve gloves, a tool pouch, and a small opening which may be used for insertion of water sprayers and/or HEPA vacuum nozzles. Although glovebags can be fabricated by the user individually before each project, most contractors prefer to purchase ready made bags.

Quality, cost, size, and style of glovebags may vary depending on the manufacturer. Many manufacturers can custom design glovebags upon the request of the user. Additionally, multiple sets of sleeves can be built into one bag if the job requires it. The overall strength of the glovebag is generally determined by its thickness. Depending on the size and type of glovebag, the costs may vary significantly. Average polyethylene glovebags should cost in the range of three to fifteen dollars a piece¹ while PVC glovebags should cost approximately seventeen to eighty dollars a piece². A typical glovebag is approximately forty to fifty inches wide by forty eight to sixty inches long³. Many glovebags are pre-labeled with appropriate OSHA and EPA precautions, ("Danger") in order to ensure compliance with the federal regulations. In most cases, it will be necessary to "double bag" asbestos waste. When disposing of glovebagged waste, it is necessary to ensure that the outermost bag contains the required wording.

In addition to the glovebag itself, there are a variety of other tools typically considered to be standard materials necessary to successfully complete the procedure. Following, is a list of these "necessary" materials:

MATERIALS

1. Glovebag (one or more depending on project size) - polyethylene or PVC
2. Pump-up garden sprayer (2-3 gallon size)
3. Amended water (surfactant)
4. Duct tape (3-inch width)
5. Polyethylene disposal bags (6 mil) labeled properly per OSHA, EPA and DOT regulations
6. Smoke tubes with aspirator bulb
7. HEPA-filtered vacuum cleaner
8. Wire saw/"Flexi-saw"
9. Utility knife with retractable blade
10. Wire cutters
11. Tin snips (if aluminum jacket is present)
12. Polyethylene plastic (roll of 4 or 6 mil)
13. Dual cartridge respirators with high efficiency cartridges
14. Disposable full-body suits with hood and feet covering
15. Small scrub brush (nylon brush)
16. Several rags
17. Wettable cloth or other patching material
18. Asbestos danger signs and labels
19. Reinsulation materials as necessary

- Note:
1. Range stated for prices as of 10/88 for standard polyethylene glovebags.
 2. Range stated for prices as of 10/88 for standard PVC glovebags.
 3. Size stated to indicate a "standard" glovebag.

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The EPA Regional Asbestos Coordinator in the area that the asbestos abatement work is taking place (see Figure XV-2) can usually provide a list of approved sites for disposal of asbestos-containing waste.

OTHER CONSIDERATIONS FOR ASBESTOS-CONTAINING WASTE DISPOSAL

One aspect that must not be overlooked when devising an asbestos-containing waste disposal strategy is that of filtering the run-off water from showers in the worker decontamination area. It is now generally accepted that filtration of asbestos-contaminated water through a five micron filter is the state of the art for asbestos removal from water. Discharge of the filtered water should be to a sanitary sewer system, or in its absence, to a septic tank and field system with adequate capacity.

If there is any uncertainty regarding water regulations in a particular area, the best course of action to follow would be to contact the state department of environmental management. Local municipalities have the final authority in regards to waste water treatment and should always be contacted for information concerning regulations.

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appropriately. When this is complete, the bundles should be neatly stacked in the truck. Care should be used so that tipping or shifting of the load is prevented.

TRANSPORTATION TO THE ASBESTOS-CONTAINING WASTE 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 pre-arranged 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 NESHAP (National Emission Standard for Hazardous Air Pollutants) and applicable local guidelines. It is best to check with state officials on these requirements.

When transporting asbestos-containing waste to any disposal location, it is important that the drivers of the vehicles be properly trained in correct waste handling procedures. It is also important that they not use excessive speeds or unusually rough roads to avoid load slippage or tipping. The driver will be responsible for retaining all dump receipts, trip tickets, transportation manifests, or other documentation of disposal. These should then be given to the building owner for his/her records.

DISPOSAL AT THE LANDFILL

Once the asbestos-containing waste truck arrives at the landfill, the driver should approach the disposal location as closely as possible for unloading of the waste materials. Bags should be taken out of the drums along with the other waste components. They should be inspected as they are off-loaded. In the event 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. Personnel off-loading the containers should wear proper protective equipment which includes disposable head, body, and foot protection. (Minimum respiratory protection requirements should include the use of half-face, air-purifying, dual-cartridge respirators equipped with high-efficiency filters.)

Upon complete removal of all containerized waste, 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. Landfill personnel should have their own personal protective equipment. If this is not the case, the contractor should supply them with protective clothing and respiratory protection.

Bags or drums should be placed intact in an excavated area and covered with a minimum of six inches of earth at the end of each working day. These areas must be clearly marked to prevent future disturbance of the waste.

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WASTE LOAD-OUT PROCEDURE

The most effective method in a waste load-out procedure is to use two teams of workers; an inside team and an outside team. Wearing appropriate respirators and protective clothing, the inside team will be 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. (The plastic bags should then be placed in the next drum to be disposed of.) It is important that no workers from the inside team exit the work area through the airlock.

In cases where the drums are not being covered with plastic bags, it becomes necessary for the inside team to assure that each drum exiting the work area be free of any dust. This may be accomplished by inspecting and wet-wiping every drum leaving the area.

Wearing dual-cartridge respirators and appropriate protective clothing, the outside team (in the waste load-out area) will post themselves at the entrance to the work area.

They will receive the drums into the load-out area from the inside team. Then, the outside team will load them into the enclosed truck. The entrance into the waste load-out area from the work area should be secured to prevent any unauthorized entry or exit.

Drums should be placed on level surfaces in the enclosed truck and packed tightly together to prevent shifting and tipping. Under no circumstances should containers ever be thrown into the truck. Also, when moving the containers, hand trucks, dollies, or pull carts should be used. In addition, it is important to instruct workers in proper lifting techniques in order to avoid back injuries. Where ramps are not possible, trucks with lift gates would be helpful for raising drums during loading.

To assure that the truck is properly enclosed, the inside or "bed" area should be lined with 2 layers of 6 mil polyethylene. First, the floor should be completely covered with a six-inch overlap of each piece. The same method should also be used when lining the sides and top of the truck. Duct tape should be used to properly secure the sheets of polyethylene. This will not only ensure additional enclosure of the asbestos-containing waste, but it will also provide for easier clean-up operations. It should be noted here that 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.

OTHER FORMS OF ASBESTOS-CONTAINING WASTE

In any asbestos abatement project, not all of the waste material that needs to be disposed of will be loose or broken apart. There are many cases in which it will be necessary to dispose of materials such as asbestos-containing floor, wall, or ceiling tiles, shingles, rugs, etc. The rule of thumb to follow 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 could possibly puncture the polyethylene enclosure. Once the materials are banded together, each bundle should be wrapped in 2 layers of 6 mil polyethylene, secured by duct tape, and labeled

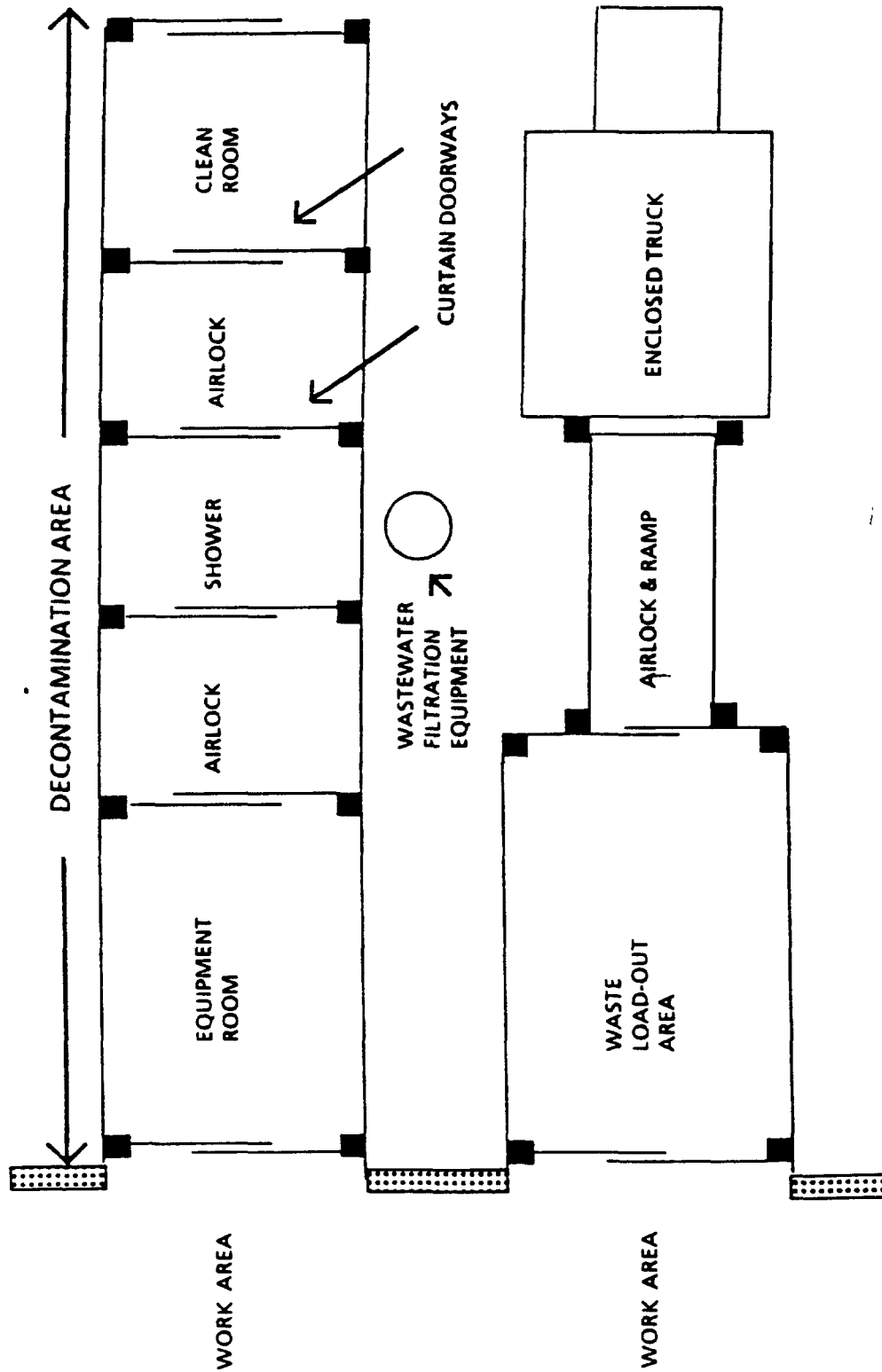


Figure XV - 1. Sketch of Typical Decontamination Area and Waste Load-out Area

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- b. Instruction on materials that should not be included in the bags (i.e., metal, sharp objects) and also that each bag should be considered "full" when it is half filled (since material saturated with water will be much heavier).
- c. Instruction on correct procedures for sealing off waste-containing bags with duct tape. Ensure that all excess air is squeezed out of bags before they are sealed (to conserve space).
- d. Discussion on the importance of ensuring that the asbestos warning label on each bag is legible, so that no bags will be disposed of mistakenly.

Once the asbestos-containing waste is securely enclosed inside the bag, the best recommended practice is to decontaminate the bag by wet wiping or HEPA vacuum them clean. The bags may then be placed in fiberboard drums with locking rims. These drums should be labeled in the same manner as the bags. To use the drums efficiently 4 or 5 bags can be placed in each drum. Important concepts that should be included when instructing workers in drum usage are:

- a. Prior to the time drums are to be used, while they are still in the waste load-out area, an effective method of contamination control is to line the outside of each drum with a plastic (garbage) bag. This outside bag should be kept on the drum while it is being filled with the asbestos-containing waste bags.
- b. Once the drum is filled, the lid or rim should be locked into place. The drum will then be ready for transportation out of the work area.
- c. Before leaving the work area (at the doorway to the waste load-out area), the plastic bag on the outside of the drum should be removed and placed in the next drum to be filled with waste.
- d. Before the drum enters the load out area, it should be hosed down and/or wet wiped to ensure that there is no residual contamination present on the outside of the drum.
- e. Immediately after this bag transfer is accomplished, the sealed drum should be moved into the waste load-out area and subsequently into the enclosed truck.

(Note: Drums may not be used in some states for asbestos removal since many of their landfills will not accept them.)

For a sketch of a typical waste load-out area, see Figure XV-1.

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PREPARATION OF ASBESTOS-CONTAINING WASTE (BEFORE TRANSPORTATION TO THE DISPOSAL SITE)

WETTING

Once the asbestos-containing waste material has been removed from the areas of concern, certain precautions must be taken before disposal operations begin. The first, and probably most important, undertaking is to ensure that all of the asbestos-containing waste has been thoroughly treated with water, or "wetted." This may be accomplished by having a water supply available in any area that abatement work is taking place (i.e., low-pressure water sprayer). As the asbestos-containing material is being removed, the material should be kept as damp as possible via a low pressure water stream. By ensuring this, the chances of airborne asbestos fiber generation are significantly reduced. Wet waste material will then be suitable for containerizing.

CONTAINERIZING

An effective way to ensure that the asbestos-containing waste has been properly packaged for transportation to the disposal site is to establish a standard procedure for bagging and handling the waste. The first step in this procedure would be to select the appropriate disposal bags (recommended: 6 mil polyethylene). These will be air-tight and puncture resistant. Also, these bags should be labeled with the OSHA required statement:

DANGER
CONTAINS ASBESTOS FIBERS
AVOID CREATING DUST
CANCER AND LUNG DISEASE HAZARD

Many asbestos supply companies have these bags available with the proper wording already pre-printed. In addition, as of January 1, 1988 updated regulations issued by the United States Department of Transportation (DOT) became effective. The new regulations require additional labeling of reportable quantities (greater than 1 pound) of asbestos waste. Also, under the new DOT regulations, asbestos is classified as a hazardous waste and therefore any container with a reportable quantity of asbestos waste must have in addition to the OSHA label the following DOT labeling:

RQ Hazardous Substance
Solid, N.O.S. (asbestos)
ORM-E, NA-9188

This warning label in addition to OSHA or EPA labeling requirements, must be affixed to all containers. Trucks and dumpsters used to haul asbestos waste are not required to show this additional labeling.

Once appropriately labeled bags are acquired, the next step is to train the abatement workers in the proper techniques for containerizing the waste materials. Important concepts of this training should include:

- a. Discussion of the importance of handling asbestos-containing waste in a careful manner to keep airborne fiber generation minimal.

**Suggested Sequenced for Cleaning Up an Asbestos
Abatement Work Area
(A Simplified Scheme)**

1. Continuous Cleaning During Abatement	7. a. Second, More Stringent Visual Inspection of the Polyethylene (outer) Layer Still in Place
2. a. Complete Gross Removal and Initiate Final Clean Up	7. b Check for possible Contamination to the Inside Layer
2. b. All Asbestos Waste Out of the Work Area	7. c If Asbestos Materials/Waste are Discovered During Inspection, Further Cleaning (wet wiping/HEPA vaccuming) Necessary
3. Visually Inspect for any Residual Asbestos in Work Area	8. a. With Outside Layer of Polyethylene Sheeting Still in Place (and critical barriers), Pre-Clearance Air Samples May be Collected
4. Clean Up Residual Asbestos Found	8. b. Pre-Clearance results indicates work area clear 8. c. If work area is still contaminated, re-clean and sample again
5. Lockdown/Encapsulating Solution Applied to Substrate and Inner Layer of Polyethylene misted to Contain Residual Asbestos Fibers	9. Outside Layer of Poly removed, critical barriers in place, Final-Clearance Air Samples collected
6. a. Lockdown Material Dried/Setup	10. Work Area Passes Final Clearance air Sampling
6. b. Inner Layer of Polyethylene Taken Down, Contained, and Disposed of as Asbestos Containing Waste	11. The Area is Cleared for Reoccupancy of Unprotected Personnel

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CLEANING UP THE DECONTAMINATION UNIT

For decontamination units that are not pre-fabricated or modular, the unit is lined with three layers of polyethylene on the floor and one or two layers on the walls (at a minimum, the walls of the equipment room should be lined with an extra layer of polyethylene). The top layer of floor poly in the equipment room should be removed at the same time the top layer of floor poly in the work area is removed, using the same procedures. This will minimize tracking contamination back into the work area. After cleanup is completed inside the work area, the polyethylene on the walls of the decontamination unit is lightly misted with amended water and folded inward. Next, the remaining layers on the floor are removed in the same manner and packaged with the other poly for disposal. The walls should be visually checked for contamination and wet wiped if necessary. The decontamination unit can now be disassembled for transport.

CLEANING UP THE ENCLOSED TRUCK

During the last disposal trip to the landfill, after the truck has been emptied of all waste materials, the polyethylene lining the inside of the truck is misted with amended water and carefully removed. Good practice should include wet wiping the floor and walls of the truck at this time. Polyethylene removed from the truck interior and the protective clothing worn by workmen conducting disposal are bagged for disposal and placed with the other materials at the dump site.

SECTION NOTE: A standard method for conducting visual inspections in asbestos abatement work areas has been adopted by the American Society of Testing and Materials (ASTM). Consultants and project inspectors may find this method useful.

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WET MOP FLOORS

After the walls are wet wiped, the floor (or the floor polyethylene) is mopped with a clean mop head wetted with amended water. (Caution: If carpet remains in place, only minimal amounts of water should be used during this process). The water should be changed frequently. Waste water from the wet wiping and mopping operations should be treated as asbestos-containing waste and dumped in the shower drain to be appropriately filtered or placed in a barrel for disposal.

WAIT OVERNIGHT/REPEAT WET WIPE AND WET MOP PROCEDURES

Frequently, abatement project specifications will call for "3-phase cleaning". This may require more time spent on the project, but if properly conducted will actually save money and prevent confusion at the conclusion of the project. After the walls and other surfaces (shelves, ledges, etc.) have been wet wiped and the floors have been mopped, activity in the area may be stopped until the following day. The next day, the same wet wiping and mopping procedures are often repeated. As an alternative to using amended water for the second wipe down, the cleaning efficiency may be increased by using a commercial cleaning product such as Endust^{PM} or PledgeTM.

VISUAL INSPECTION/RECLEAN IF NECESSARY

Work areas should be dry before the final visual inspection is conducted. The inspection is again conducted by the owner's representative and the job supervisor. All surfaces are carefully checked for visible contamination and any areas which need further cleaning are listed on paper. Ledges, tops of beams, and all other hidden locations should also be inspected for asbestos-containing dust or debris at this time.

REINSPECT/SHUT OFF NEGATIVE AIR FILTRATION UNIT

After any necessary recleaning has been conducted, the inspector and job supervisor make a final walk-through to assure the items listed have been addressed. Often, the negative air filtration units are shut off and final or "clearance" air monitoring is conducted. It is important to note however, that many project specifications may require that negative air machines be kept operating through final clearance air monitoring.

FINAL CLEARANCE MONITORING

Clearance monitoring is addressed in detail in the section on "Air Sampling Requirements." When the air sampling results indicate the airborne fiber concentration meets the predetermined criteria for clearance, the final "critical" seals on vents and stationary objects such as water fountains, electrical outlets, etc., can be removed. If the first set of air samples indicate airborne fiber concentrations in the area are above the specified "clearance level", the area must be recleaned followed again by clearance sampling. This cycle is repeated until results of airborne fiber concentrations indicate the clearance criteria have been attained.

After the area has been cleared for reoccupancy by unprotected personnel, remaining renovation can be initiated (i.e., painting walls, installing suspended ceiling, or laying carpet).

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HEPA VACUUM

The hard-to-reach places such as crevices around windows, doors, shelves, etc., can be cleaned using a vacuum equipped with a High Efficiency Particulate Air (HEPA) filter. On some projects, contractors may elect to vacuum all surface areas, beginning at the top of the wall and working downward. The HEPA filter retains the tiny fibers (down to 0.3 microns in diameter) which could pass through a standard vacuum cleaner. HEPA vacuums are available with various cannister sizes and horsepower motors. Some models have an available kit for converting a dry vacuum to a wet pick-up vacuum. Also models are available which use compressed air rather than the standard direct current. Twenty to thirty feet extension hoses are available for the larger vacuums.

REMOVE POLYETHYLENE FLOOR COVERING/REMOVE OR CLEAN CARPET

After vacuuming of these areas is completed, the polyethylene floor covering is detached from the wall, and folded inward to form a compact bundle for bagging and disposal. If a carpet is in the work area and specified for removal (removal instead of cleaning is the preferred practice), workers should lightly mist the entire carpet with amended water before detaching it from the floor and rolling it up. Once the carpet is rolled up, it can be wrapped with 6-mil poly, sealed with duct tape, and properly labeled for disposal. A note of caution: In some locations, carpet may be stuck to the floor with a glue which does not readily separate from the flooring. As the carpet is taken up, some portions of the backing may tear away and remain stuck to the floor. Several unplanned additional manhours may be required to pry or scrape up the glue-carpet spots which are left after the carpet is removed. Also, tearing of the carpet material may elevate fiber counts in air samples analyzed by phase contrast microscopy. If the carpet is not specified for removal, at least one layer of polyethylene should be left in place to protect it from residual contamination.

HEPA VACUUM

After the floor area is uncovered, corners and crevices can be cleaned with a HEPA vacuum. It may also be necessary to wet wipe certain locations.

WET WIPE WALLS

At this point the walls and floor polyethylene (if applicable) are HEPA vacuumed and/or wet wiped. (If carpet has been removed, the floor should be thoroughly cleaned). Workers should begin cleaning the areas farthest away from the negative air filtration units and use amended water to wet wipe all exposed surfaces (excluding the substrate from which the asbestos material was removed). For best results, workers should use cotton rags or lint free paper towels which are disposed of after one use. Rinsing and reuse of towels may result in smearing asbestos fibers on surfaces and not contribute to overall cleaning. Also, to avoid smearing of residual fibers, workers should wipe surfaces in one direction only. Paper towels should not be used to wipe down rough surfaces and should be discarded before they begin to deteriorate when used on smooth surfaces. Small "fibrous looking" residue which may be deposited on surfaces as a result of using deteriorated paper towels could cause a problem during the final visual inspection.

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REMOVE GROSS CONTAMINATION FROM EQUIPMENT IN WORK AREA

The next cleaning efforts should be directed toward removing gross contamination from the exteriors of the negative air filtration units, scaffolding, ladders, extension cords, hoses, and other equipment inside the work area. Cleaning can be accomplished using a combination of HEPA vacuuming and wet wiping. This is also a good time to change-out any of the filters that need replacement on the negative air filtration units.

REMOVE TOP LAYER OF FLOOR POLYETHYLENE

At this point, the top layer of 6-mil poly which has been used to cover the floor area, should be cleaned appropriately and carefully folded inward to form compact bundles for bagging and disposal. Any visible contamination which leaked through to the bottom floor layer should be removed (i.e., HEPA vacuumed, wet wiped). This material should then be bagged and disposed of according to procedures outlined earlier. Excessive time should not be spent in cleaning the floor sheets, but any obvious contamination should be cleaned, contained, and disposed of properly.

CONDUCT VISUAL INSPECTION OF ALL SURFACE AREAS/RECLEAN IF NECESSARY

After all of these cleaning tasks have taken place a thorough visual inspection of the area should be conducted. The inspector (building owner's representative) and the contractor's representative (usually the project supervisor) should check for visual contamination or residual debris on the substrate from which the asbestos-containing material has been removed. Ledges, indented corners, and other surfaces which might "catch" falling material or contain residual material must be inspected closely. A high-intensity flashlight will prove helpful during this inspection. As the building owners' representative and the contractor's representative walk through the work area, the inspection and recleaning process might be facilitated by recording on paper the items or areas which need additional cleaning. The contractor's representative is responsible for correcting any of the deficiencies noted during the inspection before beginning the next phase of work.

PERFORM FINAL WIPE DOWN OF EQUIPMENT/REMOVE FROM WORK AREA

After the work crew has completed recleaning the areas noted on the inspection list, equipment in the work area should be thoroughly cleaned (gross contamination was removed earlier). Equipment should be wet wiped, washed off in the shower at the waste load-out area, wrapped in polyethylene, or placed in plastic bags. Tools such as scrapers, utility knives, and brushes can be placed in buckets or pans (bottoms cut off of fiber board drums work well) and then sealed in plastic bags for transport to the next project. Equipment which is not needed for completion of the project should be removed from the work area. The negative air filtration units remain in place and operating for the remainder of the cleanup operation until final clearance samples are collected.

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CLEANING UP THE WORK AREA

Although cleanup is a tedious, sometimes lengthy process, it is one of the most critical tasks of the project. Successful cleanup operations require proper sequencing of tasks and great attention to detail. If these items are overlooked, much more time may be spent in the recleaning and air monitoring cycle than would have been spent to initially conduct a thorough, correct cleanup. Sequential 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 for thermal system insulation in areas such as boiler rooms may vary, depending on individual specifications and the nature of the project.

CLEANUP DURING GROSS REMOVAL

Cleaning of the work area begins almost concurrently with removal of asbestos-containing material from the substrate. Techniques for limiting fiber release and cleaning the work area during the removal phase are addressed in the section "Confining and Minimizing Airborne Fibers." 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 labeled bags for disposal. Metal shovels and other sharp objects should be avoided since they will cut and tear the floor polyethylene sheets.

FINAL CLEANUP

The discussion on final cleanup applies to the phase of the project in which all visible asbestos-containing material has been removed from the substrate and the substrate has been brushed (with nylon bristle brushes) and wet wiped. A flow chart recommending a good and feasible sequence of tasks for performing cleanup is provided at the end of this section.

REMOVE GROSS CONTAMINATION FROM WALL COVERING/OR REMOVE INNER CONTAMINATED LAYER

After all visible asbestos containing material has been removed from the substrate, the next cleaning task should be the removal of all visible asbestos contamination which has splattered or collected on the polyethylene wall coverings. Preferably, two layers of polyethylene were initially hung on the walls and the inner contaminated sheets can be removed at this point instead of cleaned. Ideally, the contaminated sheet is lightly misted with an encapsulant or "lockdown" material (see "Lockdown and Asbestos Substitute" chapter) to minimize the release of airborne fibers. After detaching or cutting this first inside layer of polyethylene from the bottom of the wall, workers should use ladders to reach the top of the wall sheet. The inner sheet of the work area enclosure should be gently detached from the top of the wall and folded inward to form a compact bundle which can be packaged in a properly labeled 6-mil polyethylene bag for disposal. Any visible debris which leaked behind the inner layer of polyethylene onto the outer (final) layer is now removed with a HEPA vacuum and/or wet wiping methods.

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Armholes and an inside pouch for tools let the worker remove insulation without exposure to asbestos fibers. A sealed side port also can be constructed to allow access for wetting the asbestos and evacuating the bag with a HEPA-filtered vacuum.⁴ Workers who use containment bags should still wear respirators in case a bag leaks.

To remove individual pipe sections or an entire pipe network, a small section (about 6 inches wide) of insulation should be removed. The pipe then can be cut into manageable lengths with a saw or torch. Exposed ends of the insulating material should be sealed with plastic and tape. If the remaining insulation is not in good condition, the entire pipe should be wrapped in 6 mil plastic. Disposal of insulation material must follow EPA procedures discussed earlier for ACM disposal (Sections 1.4 and 5.1). More information on pipe and pipe insulation removal will be provided in a future technical bulletin.

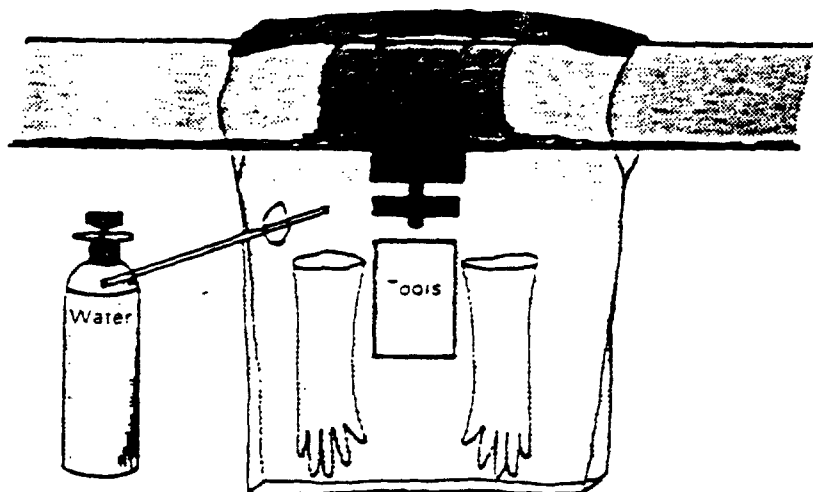


Figure 14. Custom containment bags for repairing or removing pipe insulation.

5.3. Abatement Methods for Other Types of ACM

Additional corrective action generally is not needed for other types of ACM. The special C&M program should continue until building renovation or maintenance requires ACM removal. The ACM should then be removed following the guidelines for surfacing materials (i.e., worker protection and work area containment). Removed ACM should be wrapped in 6 mil plastic sheets or placed in plastic bags, labeled as asbestos waste, and transported to a solid waste site. Unless these materials are friable, OSHA and NESHAPS regulations covering removal operations do not apply.

⁴ Seals can be checked with a flashlight and smoke from a smoke tube.

5.1.3 Encapsulation with Sealants

Encapsulation refers to the spraying of ACM with a sealant. The sealant should bind together the asbestos fibers and other material components and offer some resistance to damage from impact. Figure 13 shows an asbestos encapsulation project.

Encapsulation should be used only on granular, cementitious material—commonly known as acoustical plaster. A sealant should penetrate the ACM and adhere to the substrate (or form a tough skin over the material), withstand moderate impact, be flexible and flame-retardant, resist deterioration over time, and be non-toxic. EPA evaluated over 100 sealants, using five criteria: impact resistance, flame spread, smoke generation, toxic gas release during combustion, and adhesive/cohesive strength (USEPA 1981). The American Society of Testing and Materials (ASTM) also is developing laboratory testing criteria for sealants. Additional information on the EPA sealant study can be obtained from EPA's Office of Toxic Substances, TSCA Assistance Office (see Appendix E for phone numbers).

Although the EPA study can help building owners choose a sealant, its effectiveness on the particular ACM should still be tested on-site over several days. (ASTM is developing criteria and procedures for such on-site tests.) Do not encapsulate material that is delaminated or deteriorated, or that shows extensive damage. If delaminated, the material will be pulled down by the additional weight; if deteriorated, the ACM may be blown off by sealant application; if extensively damaged, the material may be repeatedly abused and the sealant will not hold up. The condition of the sealant on previously encapsulated materials also should be inspected. Reapplication of sealant may be necessary.

Latex paint has been used as a sealant for granular, cementitious materials. Select a brand with a high vehicle content (at least 60 percent by weight) and at least 25 percent by weight vehicle resin.⁴ For encapsulating ACM, apply paint considerably thicker than recommended for painting. Coverage should be no more than 100 sq. ft. per gallon, and should create a continuous, unbroken coating.

Apply sealants with airless spray equipment.⁵ One recommended method is to apply a light (mist) coat, then a full coat applied at a 90 degree angle to the direction of the first. If latex paint is used, the full coat can also be applied by roller before the mist coat dries.

Record the type of sealant used and the nature of the material and substrate encapsulated. This information is needed to avoid unintentional release of fibers during later remodeling or demolition.

5.2 Abatement Methods for Pipe and Boiler Insulation

Abatement methods for ACM used to insulate pipes, boilers, ducts, tanks, and related equipment are somewhat different from methods for asbestos sprayed or troweled on surfaces. When damage to pipe or boiler covering is limited, repair is the recommended abatement approach. Non-asbestos plastering can restore open joints, wrapped or plastered areas that are damaged, and areas around valves and flanges. Encapsulants can also be used as a temporary measure. Do not use duct tape; it becomes brittle after exposure to high temperatures.

Where large portions of pipe and boiler insulation must be removed, erect containment barriers and employ the full range of worker protections (see Section 5.1). Containment bags may be used instead of constructing containment barriers around the work area. These bags are available commercially. As shown in Figure 14, the bags are positioned around the pipe insulation to be removed, and sealed to the pipe with tape.

⁴ Paint constituents appear on the label of the can.

⁵ The use of respirators is recommended for applying any sealant. Solvent-based (as compared to water-based) sealants may require the use of a supplied air (Type C) respirator due to hazards from the solvents.

to outside the building will provide added protection in case of an accident. Appendix J summarizes specifications for negative air systems.

- When containment barriers are dismantled after ACM removal, the sealing tape used to attach the plastic sheets to walls and ceilings frequently removes paint. It is prudent to include the cost of repainting all walls (and ceilings, if appropriate) in estimates of asbestos removal costs.
- Asbestos waste is sometimes spilled both in and outside the work area. Containers full of wet material are very heavy and hard to transport. These containers must be sealed and handled carefully. Workers should continue to wear protective equipment during these operations. Also, disposal sites may be scarce. Some states require a disposal permit before removal begins.
- Amended water (water and wetting agents) from spray operations may leak through the polyethylene sheets and damage floors, especially tile and wood. Sealed double plastic sheets should protect the floors.

When removal and disposal operations are finished, evaluate the need for a sealant on the exposed surface. (The need to reinsulate or resoundproof with asbestos-free materials should be decided before removal begins.) Sealants generally are necessary where the underlying surfaces are porous (for example, concrete blocks or slabs), since a few fibers usually remain after removal.

Cost of asbestos removal varies widely by region and by job. Where the underlying surface must be sealed and the ACM replaced, those costs must be added to removal costs.

5.1.2 Enclosure

Enclosure involves construction of airtight walls and ceilings around the ACM. Figure 12 shows a typical enclosure. These recommendations for constructing enclosures should be followed:

- To reduce fiber release, drills used during installation should be equipped with HEPA-filtered vacuums.
- Underlying structures must be able to support new walls and ceilings.
- New construction material should be impact-resistant and assembled to be airtight.³ Gypsum panels taped at the seams, tongue-and-groove boards, and boards with spline joints all qualify. Suspended ceilings with lay-in panels are not acceptable. Joints between walls and ceilings should be caulked.
- If lights are recessed into ACM, they must be removed carefully to minimize fiber release. Lights should be reinstalled beneath the new ceiling.
- Relocation of plumbing lines and computer cables may be necessary.
- Building records must note the presence of asbestos behind the enclosure to prevent accidental fiber release during remodeling or building demolition. (The presence of ACM should have been documented as part of the special O&M program.) Signs should be posted, noting that ACM is behind the enclosure.

³ No enclosure will be totally airtight. The practices recommended here are designed to greatly reduce air movement across the enclosure boundary.

are required for removal of ACM and are highly recommended for other abatement methods, since enclosure and encapsulation may also elevate fiber levels.

The third common feature is proper work area containment. Containment typically means construction of barriers with 6 mil polyethylene plastic sheets joined with folded seams, and with sealing tape at the seams and boundaries. Some contractors have had problems attaching plastic sheets to walls. Thinner sheets or a better attachment system (for example, stapling and taping sheets to furring strips fastened to walls) may be required. (Figure 10 shows the construction of a typical containment system. Note that respirators should be worn if the ACM will be disturbed during construction.) Air locks and worker decontamination facilities with showers are recommended, as well as negative air pressure systems, described in Section 5.1.1 below.² All return air vents should be sealed to prevent asbestos contamination of the air-handling system. Without such containment measures, increased exposure for building occupants is likely. Once abatement begins, everyone not participating in the project should be kept out of the area.

The fourth common feature is the need for a rigorous postabatement cleanup. This includes wet-mopping or HEPA-vacuuming all horizontal and vertical surfaces in the work area. (Wet mopheads and cloths should be discarded in sealed plastic bags and treated as asbestos-contaminated waste.) Cleaning of surfaces outside the work area is highly recommended. Two cleanings—the second after at least 24 hours when suspended fibers have settled—will provide better assurance of fiber reduction than a single cleaning. (Section 5.4 contains additional information on cleaning and inspecting the work site.)

5.1.1 Removal, Disposal, and Replacement

Figure 11 is a photograph of a typical removal project. When removing ACM, observe the following requirements:

- The material must first be treated with a solution of water and a wetting agent to reduce fiber release. Some types of amosite-containing materials will not absorb either water or water combined with the wetting agent suggested by EPA (50% polyoxyethylene ester and 50% polyoxyethylene ether). Other wetting agents should be tested on the material for absorption. If the material will not absorb the wetting agent, undertake a dry removal using Type C respiratory protection. EPA must approve all dry removal operations. Get in touch with the NESHAPS contact in your region (see Appendix D).
- Fragile ACM must be disposed of in "leak-tight" containers—typically 6 mil polyethylene bags. Bags can be placed in 55-gallon drums for additional protection. Bags or drums must be labeled, as specified by NESHAPS (see Appendix C) or OSHA (see Appendix F).
- OSHA procedures for worker protection and decontamination, as well as for measurement of airborne asbestos, must be strictly followed (see Appendix F). While not required by law, EPA procedures for work area containment should also be followed to assure safe removal.

Research on asbestos removal plus EPA's experience with removal activities in schools since 1979 have pointed up several other important issues:

- A tear in the containment barrier is a significant exposure hazard for building occupants and should be repaired immediately. The use of negative pressure systems together with HEPA filtration (that is, low speed exhaust fans with HEPA filters) to move air from within the work area

²OSHA decontamination requirements specify worker change rooms as a minimum provision for asbestos removal projects. If negative air systems are used, "air locks" should not be airtight. That is, make-up air should pass through the air lock. See Appendix J for additional information.

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This chapter provides more detailed information on the advantages, disadvantages, applicability, and relative costs of alternative abatement methods. Information is also given on recommended work practices for worker protection, work site containment, and project surveillance. This information is provided to help building owners determine which method is most appropriate for their situation and what the abatement effort will involve. It is not intended as an instruction manual for abatement.

5.1 Abatement Methods for Sprayed- or Troweled-on Surfacing Material

Each abatement method (removal, enclosure or encapsulation) is a separate and distinct alternative. They share, however, several features. The first is the need to conduct a more detailed inspection of both the ACM to be treated and the underlying surface. Each separate, homogeneous area of ACM, usually a single room, hallway, or central space, should be reinspected. (Remember that seemingly homogeneous areas can be composed of different materials and thus require separate inspections.) It is especially important to inspect for hidden material above a suspended ceiling with lay-in panels (see Figure 9). A second round of material sampling in selected areas may help to confirm the presence of asbestos and better delineate areas needing further corrective action.

The following information should be collected on each area with ACM:

- size of the area, since this affects the cost of abatement;
- type of ceiling construction if the ceiling is coated (for example, concrete joist and beam, concrete waffle slab, steel beam or bar joist, suspended metal lath, suspended lay-in panels, tile, metal, corrugated steel), since different construction types present different control problems;
- ceiling height, which may determine the practicality of enclosing the material;
- type of wall (for example, smooth or rough concrete, block or brick, plasterboard), which may indicate whether an encapsulant is needed if material is removed;
- average thickness of ACM (and variation in thickness), since encapsulants should not be applied to thick material.

A form for collecting the necessary information was developed by EPA's Region VII Office and is included in Appendix I for illustrative purposes.

The second common feature of the three abatement methods is the need for worker protection during abatement activities. Worker protection entails not only proper training and specified work practices, but also protective equipment (special coveralls and respirators) for the workers. The OSHA standards specify three different respirators depending on the expected concentration of fibers in the work area: (1) a full- or half-face mask with either a single-use or replaceable filter, (2) a full-face mask with replaceable filter and a pump to assist breathing, and (3) a full-face mask with a self-contained or remote air supply.

NIOSH now recommends that the first type of respirator with a single-use filter not be used, because these filters have not been tested for effectiveness specifically against asbestos fibers and because they are difficult to seal properly around the face. Supplied air (type "C") units offer the most protection. Respirators

¹A letter setting forth NIOSH's concerns about these respirators was sent to respirator manufacturers on August 25, 1980. A copy of this letter appeared in the December 1980 issue of the *Journal of the American Industrial Hygiene Association*. An industrial hygienist or other appropriately trained professional should assist workers in fitting any type of respirators.

Dry Removal Techniques

Dry removal, which requires specific EPA approval, may be appropriate for some types of asbestos-containing materials which have been previously encapsulated and will not absorb amended water. There are special conditions which preclude the use of water such as a room containing electrical supply lines which cannot be de-energized during the removal project, hot steam pipes, crawl spaces, etc. Dry removal techniques can be used successfully but require much skill and attention to critical details in order to minimize airborne fibers in the workplace and to adequately confine all airborne fibers to the workplace enclosure. Proven procedures include use of large vacuum systems, small area containment with localized HEPA filtered exhaust, and recirculating HEPA units inside the work area. The dry removal procedures selected for a given situation must be carefully matched to the existing work area conditions, the type of asbestos and the skill of the work force. Adding layers of enclosure plastic, adding airlock chambers to the decontamination units, providing double or triple, rigid primary barriers (in addition to several layers of primary polyethylene), and increasing the number of negative pressure machines may be precautions that are required beyond the normal wet removal procedures. These added confining and minimizing measures obviously add cost to the project. It is always much easier to control airborne fibers using wet techniques. It is recommended that all reasonable and safe avenues for wet removal be thoroughly explored before resorting to dry removal. It must also be noted that dry removal requires job specific EPA approval, and approval is sometimes difficult to obtain. It is very important that all personnel use maximum personal protection during dry removal because of the constant and high potential for elevated airborne fiber levels.

Special Considerations

Amended water is not totally effective in controlling fibers emitted from material containing amosite asbestos. Some contractors reportedly use ethylene glycol and/or oils to help reduce amosite emissions. Others have tried an encapsulant which is diluted so that it dries slowly and does not harden before the asbestos material can be removed from the pipes or boilers. Some manufacturers are currently conducting comparative testing of these wetting methods to determine which is the most effective.

Steam or hot water distribution networks should be shut down, if at all possible, when insulation is being removed. If these systems must stay on line, special consideration must be given to avoid heat stress and skin burns.

When airline respirators are being used by workers, care must be taken not to let the airlines come into contact with hot pipes which might burn a hole in the rubber line. When airlines are worn by persons working from scaffolds, care must be taken not to wrap the airlines around objects on the ground or the scaffold. See section on Type C respirators which addresses safety considerations.

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While crews are working from scaffolds or ladders to remove all remaining residue from the ceilings, workers should also be cleaning material off the polyethylene 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 (discussed in detail in Chapter XIII).

Removal of Thermal System Insulation from Pipes, Boilers, and Tanks

There is a wide variation in the types of asbestos-containing thermal system insulation used on pipes, boilers, and tanks. Pipes may be insulated with preformed fibrous wrapping, corrugated paper, chalky mixture containing magnesia, fiber felt, and insulating cement. (Note: There are older materials labeled "magnesia" which contain asbestos and new materials also labeled "magnesia" which contain glass fiber rather than asbestos.) Usually a protective jacket, which may also contain asbestos, made of paper, tape, cloth, metal, or cement covers the insulation materials. Boilers and tanks may be insulated with asbestos "blankets" on wire lath, preformed block, or the chalky magnesia mixture which is typically covered with a finishing cement. Different approaches are typically required for removing these asbestos-containing materials than sprayed on or troweled-on ceiling insulation; however, the same protective measures are used. Careful handling and packaging is required in many cases because of the metal jackets, bands, or wire associated with the insulation materials.

Glovebags, which can be sealed around sections of pipe to form "mini-containment areas" may be used in some situations for removing pipe insulation (see Glovebag Section). Insulated objects which are not readily accessible or are too large or hot for application of the glovebag technique, may require a full area enclosure with modified removal techniques.

Because insulation on pipes, boilers and tanks may contain as much as 70% asbestos and, because areas where these materials are being removed are often confined, high airborne fiber concentrations may occur. Also, these materials are more difficult to saturate with water and may often contain amosite, which is not controlled as well with water as other types of asbestos. If these situations can not be controlled by higher air flow rates and other engineering techniques then Type C airline respirators are recommended for workers engaged in removal of asbestos from pipes and boilers.

Removal of insulation from pipes, tanks or boilers can be accomplished by two-person teams. Cuts or slits are made in the insulation material, a spray nozzle is inserted, and the material is wetted to the extent feasible. One man cuts away the insulation and bags it while the other continuously sprays the material with amended water. Any metal bands or wire that is removed should be folded or rolled and placed in polyethylene to avoid lacerating personnel.

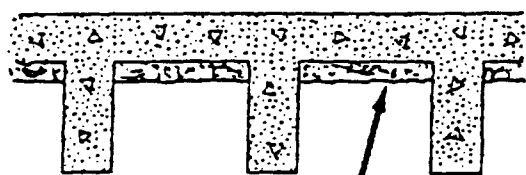
After the gross material is removed, nylon brushes are used to thoroughly clean the pipes, tanks, or boilers. (In cases when pipes are extremely hot, nylon brushes may melt and wire brushes may be the only tool available.) Particular care must be taken to clean the fittings and joints where a cement-plaster type material has been removed. After brushing, the surfaces are wet-wiped and the final cleanup phase begins.

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FIGURE XI-3

TYPES OF CEILING CONSTRUCTION

CONCRETE JOIST AND BEAM CONSTRUCTION



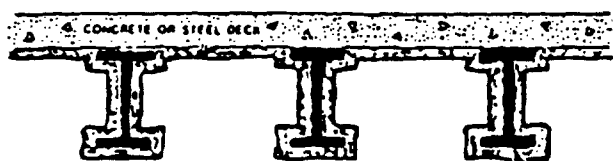
OFTEN ASBESTOS APPLIED
ONLY ON UNDERSIDE OF DECK
NOT ON JOISTS OR BEAMS

CONCRETE WAFFLE SLAB CONSTRUCTION



ASBESTOS USUALLY
UNIFORM THICKNESS

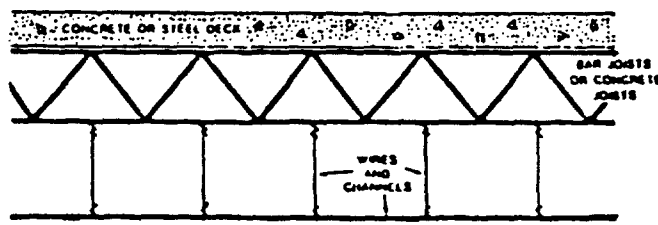
STEEL BEAM CONSTRUCTION



SPRAYED-ON
ASBESTOS

STEEL
BEAMS

SUSPENDED CEILING CONSTRUCTION



ASBESTOS USUALLY SPRAYED ON EXPANDED METAL LATH

Excerpted from Asbestos Exposure Assessment In Buildings, Inspection Manual, EPA.
October, 1982.

The first step in the removal process is to thoroughly wet the ceiling material with a low pressure mist of amended water. The material should be misted lightly with amended water to initially wet the surface, then a saturation coat is applied. The material can be wetted using a low pressure pump system or water hose with garden sprayer attached which can mix the wetting agent with the water. A hand pump garden sprayer can be used for small projects. Application with large pump systems or airless sprayers may cause leakage behind the barrier seals resulting in contamination of the walls and floors. Also, the initial impact of water applied with high pressure may cause elevated airborne fiber concentrations, therefore low pressure and careful technique in application should be used. Time should be allotted between spraying with amended water and removal to provide for maximum penetration into the material. If the time frame allows, the ceiling material should be thoroughly saturated with amended water the night before removal starts. (Note: the added weight of the amended water may cause delamination of this material overnight.)

Removal of ceiling material is carried out in two stages -- gross and secondary removal. Gross removal is typically conducted with a three or four man team. Two men working from 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. Rubber dust pans, plastic snow shovels, push brooms, and standard house brooms should be used to collect and bag the wet material. Avoid using metal shovels or dust pans that can cause inadvertent tears in the polyethylene floor barriers. The crew that bags the material also repositions the scaffold as needed, relocking the wheels after each move. If several crews are removing material, it may be more time efficient to designate a "spray" person who walks from one area to the next, keeping the material on the ceiling and the floor wet and misting the air to maintain low airborne fiber concentrations. The spray person can also check for damaged floor barriers and promptly repair them.

Bags containing the waste material are processed for waste load-out, either by wet wiping, placing in another "clean" bag, or placing into fiber drums. (See Waste Disposal Requirements Section.) All bags should be removed from the work area at least by the end of the work day. Removal of bags on a continual basis provides for easier movement (particularly if workers are wearing air-supplied respirators) in the work area.

After removing as much of the sprayed-on material as possible with scrapers, crews begin secondary removal. Depending on the type of substrate (material underneath the friable insulation), various techniques and tools may be required. Common types of ceiling construction to which friable insulation materials may be applied include concrete, 3 coat plaster system, suspended metal lath, concrete joists and beams, metal deck, corrugated steel, steel beam or bar joist. Figure XI-3 illustrates some of these ceiling types. The surface substrate may be smooth, rough, or pitted and will affect the difficulty of secondary removal. Typically a combination of brushing and wet wiping is used to remove the remaining residue. Nylon bristled 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 substrate which might be mistaken as visual contamination. High efficiency particulate air (HEPA) vacuum cleaners are also useful for removing "hard-to-get-to" residue.

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Table XI-1

**EQUIPMENT USED FOR REMOVAL OF
FRIABLE INSULATION MATERIALS**

Portable High Efficiency Particulate Air (HEPA) filtered, exhaust units

Replacement filters

Flexible or rigid ducts

HEPA vacuum cleaner

Electrical extension cords

Garden hose

Garden spray bottle attachments for the water hose

Ground Fault Circuit Interrupter (GFCI)

Hand pump garden sprayer (extra long hose, if needed)

Wetting agent (50% polyoxyethylene ether and 50% polyoxyethylene ester or equivalent)

Stiff scraper, ranging in size from narrow, putty-knife type to 4 inch wide blades and 6 inch width scrapers mounted on 6 foot long wooden handles

Nylon brushes of various sizes

Plastic dust pans

Plastic snow shovels

Brooms - standard house and push brooms

Scaffolds with railing

6 mil polyethylene bags for holding waste

Wood stepladders of appropriate height

Glovebags (for pipes) - see Glovebag Section equipment list

Duct tape

Temporary lighting

Ventilation smoke tubes and bulbs

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The positive effects of wet removal can be further enhanced by adding a wetting agent to the water. The wetting agent (i.e. surfactant) is a combination of chemicals which aids in the penetration of water into the material and increases the probability of individual fiber wetting. Various wetting agents are available which have been used in the agricultural industry and fire fighting profession for many years. 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. This wetting agent is not as effective with materials which contain a high percentage of amosite asbestos because amphiboles (i.e. amosite) are hydrophobic.

Removal of Sprayed or Troweled Friable Surfacing Materials from Ceilings

At this point of the abatement project, the work area has been sealed off with at least two layers of 6 mil polyethylene on the floors and two layers of 4 mil polyethylene on the walls (see section on Preparation of Work Area). The decontamination unit and negative air filtration units are in place, and the scaffolding, ladders, various sizes of short- and long-handled scrapers and other removal equipment have been brought into the work area. (See the Removal Equipment List, Table XI-1.)

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3. Before removal begins, check the availability of a 20 amp circuit. Most negative air machines require 18 amps for start-up and 15 amps during normal operation.
4. Negative air units usually pull less volume than the rating assigned by the manufacturer. For instance, a unit rated at 2,000 cfm will typically pull 1300-1500 cfm. Also, as filters load, the cfm is reduced. Note: The reduced flow volume at the maximum accepted pressure drop (see manufacturer's literature) should be the criteria used for this calculation. Adjust your calculations accordingly for the number of units necessary.
5. Start the negative air system before beginning work and check to see if it is functioning properly. Make sure there is adequate makeup air, otherwise the polyethylene may be pulled away from the walls.
6. Smoke tubes are useful for checking airflow inside the containment.
7. Use heavy duty extension cords to energize the negative air filtration units. If a series of cords are connected, take necessary precautions to avoid shock hazards. Make sure the temporary electrical system is properly grounded.
8. As a rule of thumb, the containment area should be no larger than 10,000 square feet for efficient use of a negative air filtration system.
9. The negative air system is most effective in reducing fiber concentrations when laborers start removal at the farthest point from the negative air units and work toward them.
10. When venting the negative air filtration exhaust outside a window, a good seal can be formed by placing a piece of plywood with a hole cut for the flex duct in the window and sealing it with duct tape. Another seal can be formed by placing a piece of 6 mil polyethylene over the plywood template and cutting a slit in it for insertion of the exhaust duct. Tape is used to seal the space around the slit in the polyethylene and the duct.
11. The use of supplied air respirators will increase the air pressure in the work area. Negative air filtration units should always be used in conjunction with type C respirators to prevent build-up of positive pressure.

Wet Removal Techniques

EPA regulations which cover the removal of asbestos material (40 CFR, Part 61, Subparts A&B, 1973) require wetting the material before removal begins and keeping it wet as it is removed and while it is being bagged.

Two advantages to the use of wet methods for removing asbestos materials include a reduction in airborne fiber concentrations which are generated during removal and a reduction in the effort required to remove the material. Wet removal is based on the ability of water to lower the potential for the asbestos-containing material to release airborne asbestos fibers and increase the settling rate of fibers that are released. Airborne fiber concentrations may be reduced significantly by using wet removal techniques rather than dry.

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be put back in place, the unit turned on, and the prefilter positioned on the intake grill. Whenever the HEPA filter is replaced, the prefilter and intermediate filter should also be replaced.

When several exhaust units are used to ventilate a work area, negative pressure can be maintained during the HEPA filter replacement and the direction of air flow into the work area will be maintained. If only two exhaust units are operating on-site, a backup unit should be available and operating before an original unit is shut down for HEPA filter replacement. An abatement enclosure should never have only one exhaust unit operating. A failure of this sole unit, for any reason, would eliminate the negative pressure in the work area. Thus, the risk of asbestos fiber release to the outside environment is controlled with additional unit(s).

Any filters used in the system may be replaced more frequently than the pressure drop across the filters indicates is necessary. Experience has shown that prefilters, for example, should be replaced two to four times a day or when accumulations of particulate matter become visible. Intermediate filters must be replaced once every day or so, and the HEPA filter may be replaced at the beginning of each new project. (Used filters must be disposed of as asbestos-containing waste). Conditions in the work area dictate the frequency of filter changes. In a work area where fiber release is effectively controlled by thorough wetting and good work practices, fewer filter changes may be required than in work areas where the removal process is not well controlled. It should also be noted that the collection efficiency of a filter generally improves as particulate accumulates on it. Thus, filters can be used effectively until resistance (as a result of excessive particulate loading) diminishes the exhaust capacity of the unit.

Dismantling The System

As gross removal nears completion, filters should be checked for loading and replaced if necessary. If a prefilter is being used on the outside of the exhaust unit, it should be removed before final cleanup begins. When the negative air system is shut down at the end of the project, the filters should be left in the negative air filtration unit and the openings sealed with polyethylene and duct tape and/or sprayed with spray polyethylene to avoid spreading contamination when the unit is moved from the work site. Filters in the exhaust system should not be replaced after final clearance sampling is complete in order to avoid any risk of re-contaminating the area.

Tips For Using Negative Air Pressure Systems:

1. Check the integrity of the gasket between the HEPA filter and housing each time the filter is changed or after the unit has been transported to a new location.
2. A general rule of thumb for filter life during "average" removal is:
 - 2 hours for the 1/2" pre-filter
 - 24 hours for the 2" pre-filter
 - 700 hours for the 12" HEPA filter

Changing out the 1/2" prefilter frequently (every 20-30 minutes) during "heavy" removal will prolong the life of the much more expensive HEPA filter.

air. Also, until the results of final clearance air samples are known, the confining and minimizing aspects of negative pressure containment are needed to ensure leakage of contaminated air outside the enclosure does not occur.

To ensure continuous operation (and therefore continuous negative pressure differential), a spare negative pressure exhaust unit(s) should be readily available at all times.

Filter Replacement

All filters must be accessible from the work area or "contaminated" side of the barrier. Thus, personnel responsible for changing filters while the negative pressure system is in use should wear approved respirators and other protective equipment. The operating life of a HEPA filter depends on the level of particulate contamination in the environment in which it is used. During use, filters will become loaded with dust, which increases resistance to air flow and diminishes the air-handling capacity of the unit. The difference in pressure drop across the filters between "clean" and "loaded" conditions is a convenient means of estimating the extent of air-flow resistance and determining when the filters should be replaced.

When the pressure drop across the filters (as determined by the Magnehelic gauge or manometer on the unit) exceeds the pressure specified by the manufacturer, the prefilter should be replaced first. The prefilter, which fan suction will generally hold in place on the intake grill, should be removed with the unit running by carefully rolling or folding in its sides. 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 and labeled, and disposed of as asbestos waste. A new prefilter is then placed on the intake grill. Filters for prefiltration applications may be purchased as individual precut panels or in a roll of specified width that must be cut to size.

If the pressure drop still exceeds the manufacturer's specified pressure 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 sealable plastic bag (appropriately labeled) and disposed of as asbestos waste. A new replacement filter is then installed and the intake grill or filter access closed. Some brands of negative air machines require removal of the prefilter to gain access to the intermediate filter. This filter should be replaced as the last step of replacing the intermediate filter.

The HEPA filter should be replaced if prefilter and/or intermediate filter replacement does not restore the pressure drop across the filters to its original clean 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. Used HEPA filters should be placed in a sealable plastic bag (appropriately labeled) and disposed of as asbestos waste. The gasket between the filter and the housing should be inspected for any gaps or cracks. Worn gaskets should be replaced as needed. A new HEPA filter (structurally identical to the original filter) should then be installed. The intake grill and intermediate filter should

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USE OF THE NEGATIVE PRESSURE SYSTEM

Testing The System

The negative pressure system should be tested before any asbestos-containing material is wetted or removed. After the work area has been prepared, the decontamination facility set up, and the exhaust unit(s) installed, the unit(s) should be started (one at a time). Observe the barriers and plastic sheeting. The plastic curtains of the decontamination facility should move slightly in toward the work area. The use of ventilation smoke tubes and an aspirator bulb is another easy and inexpensive way to visually check system performance and direction of air flow through openings in the barrier. For example, smoke emitted on the inside of the work area at a barrier should not leak 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.

Another test method for negative pressure is to use a Magnehelic gauge (or other instrument) to measure the static pressure differential across the barrier. The measuring device must be sensitive enough to detect a relatively low pressure drop. A Magnehelic gauge with a scale of 0 to 0.25 or 0.50 inch of H₂O and 0.005 or 0.01 inch graduations is generally adequate. The pressure drop across the barrier is measured from the outside by punching a small hole in the plastic barrier and inserting one end of a piece of rubber or Tygon tubing (be sure to seal around tubing if tube is left in place). The other end of the tubing is connected to the "low pressure" tap of the instrument. The "high pressure" tap must be open to the atmosphere. The pressure is read directly from the scale. After the test is completed, the hole in the barrier must be patched. Instruments are also available which monitor the pressure drop continuously. These units can be connected to a strip chart recorder to provide continuous documentation of negative pressure. An audible and/or visible alarm may be used to alert the project manager of a severe drop in pressure. Typically, a pressure drop of 0.03 inches of water is maintained throughout the asbestos abatement project (this pressure drop is affected by the air change rate).

Use of System During Removal Operations

The exhaust units should be started just before beginning removal (i.e., before any asbestos-containing material is disturbed). After removal has begun, the units should run continuously to maintain a constant negative pressure until decontamination of the work area is complete. The units should not be turned off at the end of the work shift or when removal operations temporarily stop.

Employees should start removing the asbestos material at a location farthest from the exhaust units and work toward them. If an electric power failure occurs, removal must stop immediately and should not resume until power is restored and exhaust units are operating again.

Because airborne asbestos fibers are microscopic in size and tend to remain in suspension for a long time, the exhaust units must keep operating throughout the entire removal, decontamination, and final clearance processes.

Leaving the negative pressure system operating during the final clean-up and clearance process allows the suspended fibers the potential to be "cleaned" from the

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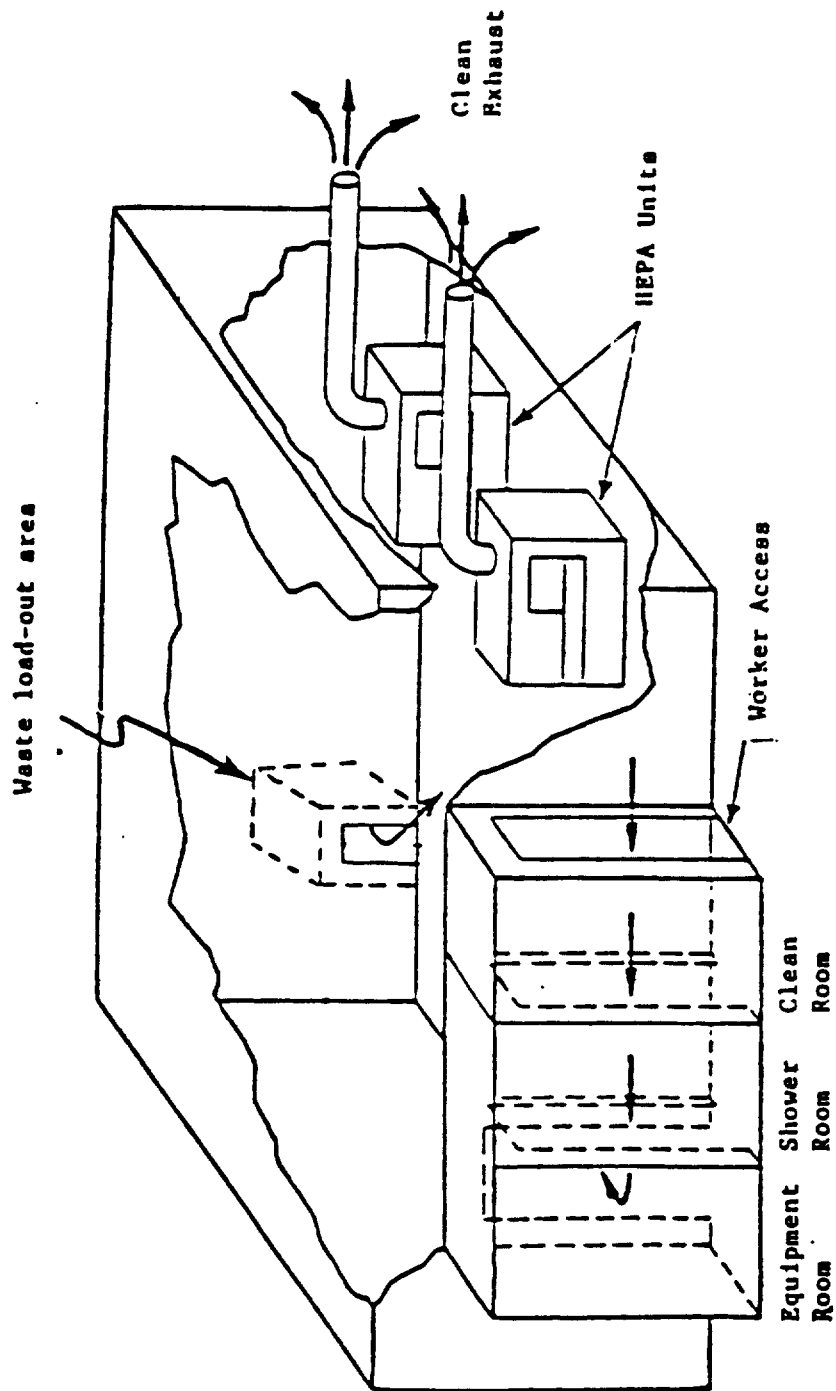


Figure XI-2. Schematic representation of negative air HEPA system in place.

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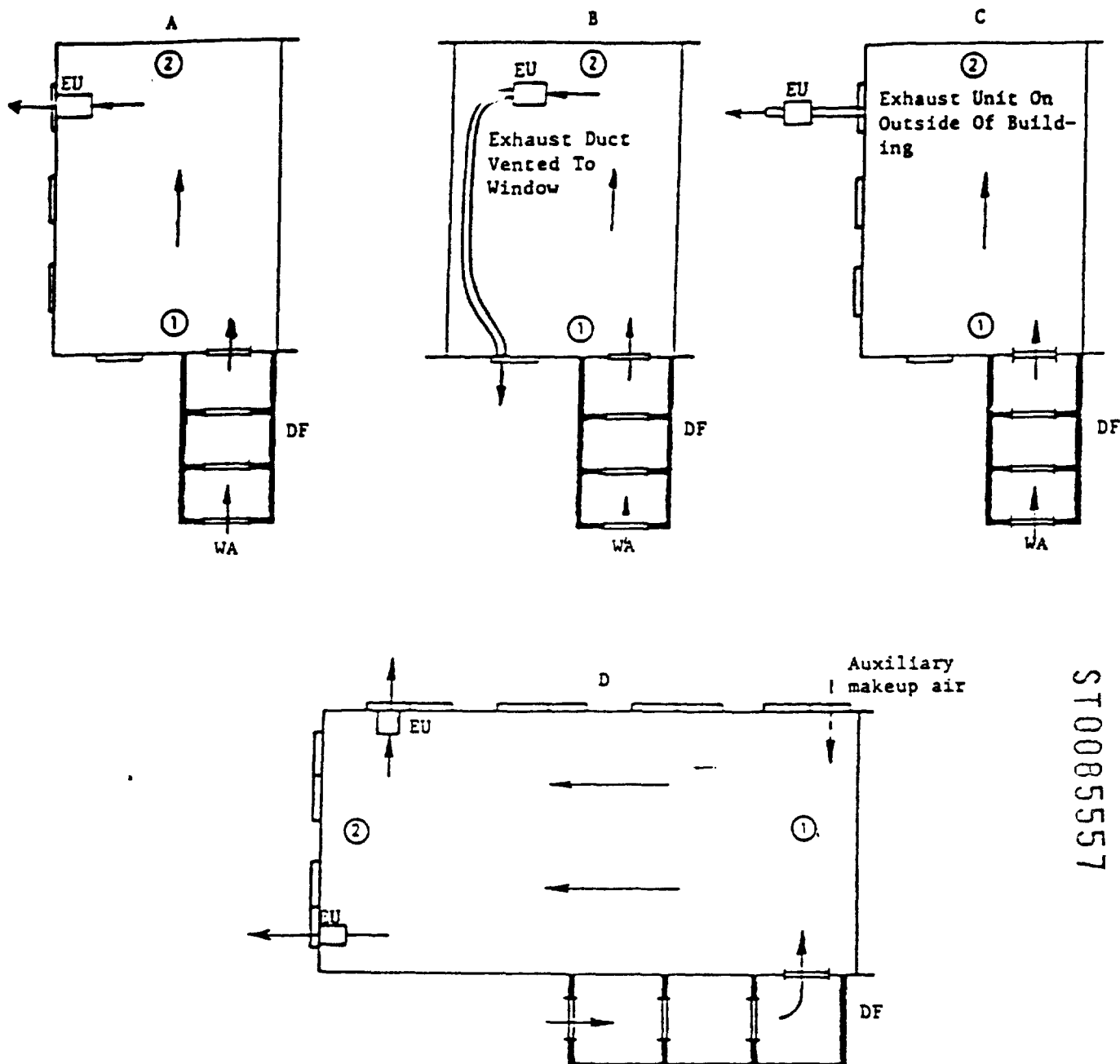


Figure XI-1. Examples of negative pressure systems. DF, Decontamination Facility; EU, Exhaust Unit; WA, Worker Access; A, Single-room work area with multiple windows; B, Single-room work area with single window near entrance; C, Single-room work area with exhaust unit placed on the outside of the building; D, Large single-room work area with windows and auxiliary makeup air source (dotted arrow). Arrows denote direction of air flow. Circled numbers indicate progression of removal sequence.

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Additional makeup air may be necessary to avoid creating too high of a pressure differential, which could cause the plastic closings and temporary barriers to detach from the walls and fall. Additional makeup air also may be needed to move air most effectively through the work area. Supplemental makeup air inlets may be made by making openings in the plastic sheeting that allow air from outside the building into the work area. Auxiliary makeup air inlets should be as far as possible from the exhaust unit(s) (e.g., on an opposite wall), off the floor (preferably near the ceiling), and away from barriers that separate the work area from occupied clean areas. They should be constructed in such a fashion (using weighted flaps, etc.) that allow the openings to be sealed in case of accidental pressure differential loss. Also, the openings should be resealed whenever the negative pressure system is turned off after removal has started. Because the pressure differential (and ultimately the effectiveness of the system) is affected by the adequacy of makeup air, the number of auxiliary air inlets should be designed and placed in order to maintain adequate pressure differential and to maximize air circulation throughout the work area. Figure XI-1 presents examples of negative pressure systems denoting the location of HEPA-filtered exhaust units and the direction of air flow. Figure XI-2 is a schematic representation of negative air HEPA system in place.

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SETUP AND USE OF A NEGATIVE PRESSURE SYSTEM

Determining Approximate Ventilation Requirements For a Work Area

Experience with negative pressure systems on asbestos abatement projects indicates a recommended minimum rate of one air change every 15 minutes. The volume (in ft^3) of the work area is determined by multiplying the floor area by the ceiling area and height. The total volumetric air flow requirement (in ft^3/min) for the work area is determined by dividing this volume by the recommended air change rate (i.e., one air change every 15 minutes).*

**Total ft^3/min = Volume of work area (in ft^3)/15 min

*The recommended air exchange rate is based on engineering judgment.

**This formula is expressed differently from the one on Page 5, but both are correct and will yield the same result.

The number of units needed for the application is determined by dividing the total ft^3/min by the rated capacity of the exhaust unit.

$$\text{Number of units needed} = \frac{\text{Total } \text{ft}^3/\text{min.}}{\text{Capacity of unit (ft}^3/\text{min.)}}$$

Location of Exhaust Units

The exhaust unit(s) should be located so that makeup air enters the work area through the decontamination facility and other make up air sources traverse the work area as much as possible. This may be accomplished by positioning the exhaust unit(s) at a maximum distance from the worker access opening or other makeup air sources.

Wherever practical, work area exhaust units can be located on the floor in or near unused exterior doorways or windows. The end of the unit or its exhaust duct should be placed through an opening in the plastic barrier or wall covering. The plastic around the unit or duct should then be sealed with tape.

Each unit must have temporary electrical power (115V A.C.). 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 not be 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 workers' way to protect the cords from traffic, sharp objects, and pinching.

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. Windowpanes may have to be removed temporarily.

filter should be marked with: the name of the manufacturer, serial number, air flow rating, efficiency and resistance, and the direction of test air flow.

Prefilters, which protect the final filter by removing the larger particles, are recommended to prolong the operating life of the HEPA filter. Prefilters prevent the premature loading of the HEPA filter. They can also save energy and cost. One (minimum) or two (preferred) stages of prefiltration may be used. The first-stage prefilter should be a low-efficiency type (e.g., for particles 10 μm and larger). The second-stage (or intermediate) filter should have a medium efficiency (e.g., effective for particles down to 5 μm). Various types of filters and filter media for prefiltration applications are available from many manufacturers. Prefilters and intermediate filters should be installed either on or in the intake grid of the unit and held in place with special housings or clamps.

Instrumentation

Each unit should be equipped with a Magnehelic gauge or manometer to measure the pressure drop across the filters which would indicate when filters have become loaded and need to be changed. The static pressure across the filters (resistance) increases as they become loaded with dust, affecting the ability of the unit to move air at its rated capacity.

ELECTRICAL

General

The electrical system should have a remote fuse disconnect. The fan motor should be totally enclosed, fan-cooled, and the nonoverloading type. The unit may use a standard 115-V, single-phase, 60-cycle service. All electrical components must be approved by the National Electrical Manufacturers Association (NEMA) and Underwriter's Laboratories (UL).

Fans

The motor, fan, fan housing, and cabinet should be grounded. All units should have an electrical (or mechanical) lockout to prevent the fan from operating without a HEPA filter.

Instrumentation

An automatic shutdown system that would stop the fan in the event of a major rupture in the HEPA filter or blocked air discharge is recommended. Optional warning lights are recommended to indicate normal operation, too high of a pressure drop across the filters (i.e., filter overloading), and too low of a pressure drop (i.e., major rupture in HEPA filter or obstructed discharge). Elapsed time meters may also be purchased to show the total accumulated hours of operation of the negative pressure units.

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MECHANICAL SPECIFICATIONS

Fans

The fan for each unit should be sized to draw a desired air volume through the filters in the unit at a specified static pressure drop (see manufacturer's literature for this information). The unit should have an air-handling capacity of at least 1,000 to 2,000 cubic feet per minute (CFM or ft³/min) (under "clean" filter conditions). The fan should be of the centrifugal type.

For large-scale abatement projects, where the use of a larger capacity, specially designed exhaust system may be more practical than several smaller units, the fan should be appropriately sized according to the proper load capacity established for the application, i.e.,

$$\text{Total ft}^3/\text{min (load)} = \frac{(\text{Volume of work area in ft}^3)(\text{air changes/hour})}{60 \text{ min/hour}}$$

Smaller-capacity units (e.g., 1,000 ft³/min) equipped with appropriately sized fans and filters may be used to ventilate smaller work areas. The desired air flow could be achieved with several units.

Filters

The final filter must be the HEPA type. Each filter should have a standard nominal rating of at least 1,100 ft³/min with a maximum pressure drop of 1 inch H₂O clean resistance. This pressure drop will increase as the filters load and the manufacturer's literature will indicate a clean filter pressure drop and a recommended maximum allowable pressure drop for dirty filters. The filter media (folded into closely pleated panels) must be completely sealed on all edges with a structurally rigid frame and cross-braced as required to prevent air bypassing the filter. Exact dimensions of the filter should correspond with the dimensions of the filter housing inside the cabinet or the dimensions of the filter-holding frame. The recommended standard size HEPA filter is 24 inches high x 24 inches wide x 11-1/2 inches deep. The overall dimensions and squareness should be within 1/8 inch.

A continuous rubber gasket must be located between the filter and the filter housing to form a tight seal. The size of the gasket material is dependent upon the manufacturer. (Some manufacturers use gaskets that are approximately 1/4 inch thick and 3/4 inch wide.) This gasket should be checked periodically for cracks and gaps. Any break in this gasket may permit significant leakage of contaminated air. Leaks in the gasket or filter will be indicated by lower than normal "clean resistance" pressure.

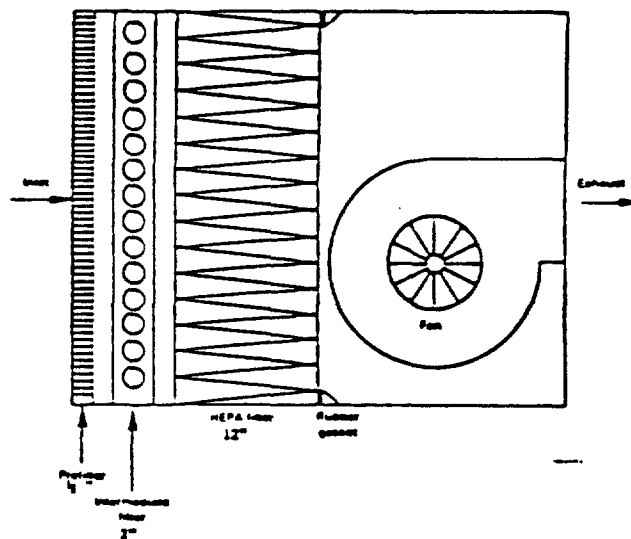
Each filter should be individually tested and certified by the manufacturer to have an efficiency of not less than 99.97 percent when challenged with 0.3 micrometers (um) dioctylphthalate (DOP) aerosol. Testing should be in accordance with Military Standard Number 282 and Army Instruction Manual 136-300-175A. Each filter should bear a UL586 label to indicate ability to perform under specific conditions. Each

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MATERIALS AND EQUIPMENT

The Portable, HEPA-Filtered, Powered Exhaust Unit

The exhaust unit establishes lower air pressure inside than outside the enclosed work area during asbestos abatement by moving air from the contained work area to the outside. Basically, a unit consists of a cabinet with an opening at each end, one for air intake and one for exhaust. 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.



Sketch of HEPA-filtered exhaust unit.
(Note: Other designs are available.)

Portable exhaust units used for negative pressure systems in asbestos abatement projects should meet the following specifications.

STRUCTURAL SPECIFICATIONS

The cabinet should be ruggedly constructed and made of durable materials to withstand damage from rough handling and transportation. The width of the cabinet should be less than 30 inches to fit through standard-size doorways. Appropriate cabinet seals should prevent asbestos-containing dust from being emitted during use, transport, or maintenance. There should be easy access to all air filters from the intake end, the filters must be easy to replace. The unit should be mounted on casters or wheels so it can be easily moved. It also should be accessible for easy cleaning.

**RECOMMENDED SPECIFICATIONS AND OPERATING
PROCEDURES FOR THE USE OF NEGATIVE PRESSURE
SYSTEMS FOR ASBESTOS ABATEMENT***

This section provides guidelines for the use of negative pressure systems in removing asbestos-containing materials from buildings. The manufacturer's instructions for equipment use should be followed for negative air filtration units, as well as all other equipment discussed in this manual. A negative pressure system is one in which the static air pressure in an enclosed work area is lower than that of the environment outside the containment barriers.

The pressure gradient is maintained by moving air from the work area to the environment outside the area via powered exhaust equipment (negative air filtration unit) at a rate that will support the desired air flow and pressure differential. Thus, the air moves into the work area through designated access spaces and any other barrier openings. Exhaust air is filtered by a high-efficiency particulate air (HEPA) filter to remove asbestos fibers.

The use of negative pressure during asbestos removal helps protect against the large-scale release of fibers to the surrounding area in case of a breach in the containment barrier. A negative pressure system also can reduce the concentration of airborne asbestos in the work area by increasing the dilution ventilation rate (i.e., diluting contaminated air in the work area with uncontaminated air from outside) and exhausting contaminated air through HEPA filters. The circulation of fresh air through the work area reportedly also improves worker comfort by increasing the cooling effect, which may aid the removal process by increasing job productivity.

*Information in this section is taken in part from EPA Report Number 560/5-85-024, Guidance for Controlling Asbestos-Containing Materials in Buildings, June 1985.

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CONFINING AND MINIMIZING AIRBORNE FIBERS

The preparation phase of an abatement project is directed toward containing the airborne fibers which will be generated during removal, primarily by constructing barriers with polyethylene sheeting. This containment effort, along with measures to minimize airborne fiber concentrations, is continued throughout the removal phase. The primary methods for contaminant control are the use of wet removal techniques and the use of negative pressure filtration systems accompanied by frequent clean up in a work area sealed with polyethylene.

Negative Pressure Filtration Systems

The planning strategy for the use of negative pressure systems in abatement work includes two main goals.

- Changing air within the containment area at a minimum of every 15 minutes while filtering the exhausted air through HEPA filters.
- Establishing conditions in which air from all portions of the sealed zone is being pulled toward the negative pressure fans and HEPA filters.

Negative pressure systems should be used on an abatement project to accomplish several positive effects.

- Containment of airborne fibers even if the barrier is ripped or punctured.
- Lower concentration of airborne fibers in the work area.
- Worker comfort and increased productivity.
- Improved efficiency in final cleanup.

Negative pressure filtration units are known by several different names including Micro-Trap, TM Red Baron, TM Hog, TM micro-filter, HEPA units and negative pressure system. Prototypes for use in asbestos abatement were developed in the latter 1970's. The concept of air filtration systems as a primary control technique on asbestos abatement projects was adopted by EPA in 1983. A general discussion on negative air systems is provided in the following pages which are reproduced with some modifications from EPA report number 560/5-85-024, Guidance for Controlling Friable Asbestos-Containing Materials in Buildings, June 1985 (The "Purple Book").

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Waste Load-Out Area

The waste load-out area (separate from the decontamination unit and not used for personnel egress) 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 airlock between the exit of the load-out area and an enclosed truck (see Figure X-1).

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; the bagged material can be placed in a second clean bag. To save clean-up time, fiber drums can be covered with an outside bag of polyethylene before they are taken into the work area. The bag can be removed before taking the drum into the load-out area.

The clean room, shower, and equipment room must be sealed completely to ensure that the sole source of air flow through these areas originates from uncontaminated areas outside the asbestos removal, demolition, or renovation enclosure. After construction of the enclosure is completed, a ventilation system(s) should be installed to create a negative pressure within the enclosure with respect to the area outside the enclosure. Such ventilation systems are discussed in detail in Section X1.

There are several prohibited activities in the work area including, eating, drinking, smoking, or chewing gum or tobacco.

Another important reason for following proper personal hygiene procedures is to avoid potential secondary exposures such as family member exposure or auto contamination.

ST0085549

Clean Room

As described in the OSHA standard (1926.58) the clean room is an uncontaminated room having facilities for the storage of employees' street clothing and uncontaminated materials and equipment. It is an area in which employees remove their street clothes, store them, and don their respirators and disposable protective clothing. This room is where workers dress in clean clothes after showering. Furnishings for the clean room should include: benches, lockers for clothes and valuables, and nails or hooks for hanging respirators. Extra disposable coveralls and towels can be stored in the clean change room.

Shower Room

The shower should have on either side of it, 2 airlocks, with both the clean and dirty change rooms on either side of the airlocks (see Figure X-1). 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. Cold and hot water should be supplied with separate controls.

Shower wastewater should be drained, collected and filtered through a system before disposal into the sanitary sewer. A system containing a series of several filters with progressively smaller pore size (100, 50, 5 micron) is recommended to avoid rapid initial clogging of filtration system by larger particles. Wastewater may need to be retained in sealed barrels or containers and/or holding tanks for appropriate disposal. For example, Alabama, Georgia, Maryland and New Jersey have written specifications for handling shower wastewater.

Equipment Room

This area, also called the dirty change room, is the contaminated area where workers remove their protective coveralls and where equipment, boots or shoes, hardhats, 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 into the shower and thoroughly soaked with water before taking off. The equipment room will probably require cleanup several times daily to prevent asbestos materials from being tracked into the shower and clean rooms.

Airlocks

Airlocks are formed by overlapping two sheets of polyethylene at the exit of one room and two sheets at the entrance to the next room with three feet of space between the barriers (see Figure X-1). There are various methods used for constructing airlocks including a hatch type construction and a slit and cover design.

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**SEQUENCE OF PROCEDURES FOR
ENTERING and EXITING the WORK AREA**
(to be used in conjunction with FIGURE X-1)

IN THE CLEAN ROOM, WORKER:

1. Enters clean room
2. Removes clothing, places in locker
3. Puts on nylon swim suit (optional)
4. Puts on clean coveralls
5. If separate disposable foot coverings are used, these are put on
6. Applies tape around ankles, wrists, etc.
7. Inspects respirator, puts it on, checks fit
8. Puts on hood over respirator headstraps
9. Proceeds to equipment room

IN THE EQUIPMENT ROOM, WORKER:

10. Puts on any additional clothing - deck shoes, hard hat, etc.
11. Collects necessary tools and proceeds to WORK AREA

IN THE WORK AREA, WORKER:

12. Brushes off contamination

IN THE EQUIPMENT ROOM, WORKER:

13. Removes all clothing except respirator
14. Places disposable protective clothing in a bag or bin
15. Stores any other contaminated articles
16. Proceeds to shower

IN THE SHOWER, WORKER:

17. Washes respirator and soaks filters (without removing)
18. Removes respirator, washes with soap and water
19. Washes swim suit
20. Thoroughly washes body and hair

IN THE CLEAN ROOM, WORKER:

21. Dries off, dresses in clean coveralls or street clothes
22. Cleans and dries respirator, replaces filters (if applicable)

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Nonessential personnel should not be permitted to enter the work area. A job log should be maintained on-site (in the clean area) for recording who enters the work area and the time each person enters and exits the work zone. The project supervisor (or designee) should be sure the log is maintained on a daily basis.

ESTABLISHING A DECONTAMINATION UNIT

Employers involved in asbestos removal, demolition, or renovation operations must provide their employees with hygiene facilities to be used to decontaminate asbestos-exposed workers, equipment, and clothing before such employees leave the work area. The decontamination station is designed to allow passage to and from the work area during asbestos operations with minimal leakage of asbestos-containing dust to the outside. A typical decontamination unit consists of a clean change room, a shower, and an equipment room separated by airlocks. The work area will be kept under negative air pressure 24 hours a day, including weekends, for the duration of the project.

Materials used to construct a typical unit include: 2-inch by 4-inch lumber for the frame, $\frac{1}{2}$ inch to $\frac{3}{4}$ -inch plywood or 6 mil poly for the walls, duct tape, staples and nails. The floor should be covered with three layers of 6 mil polyethylene.

Sections of the decontamination unit can be built separately to allow for easy disassembly and re-use (frames only, not poly) at other areas of buildings or at other job sites. Designs of decontamination stations may vary with each project depending on the size of the crew and the physical constraints imposed by the facility.

Customized trailers which can be readily moved from one location to the next are also used as decontamination stations. These units typically cost \$20,000-\$50,000 depending on the size and features. A company conducting work at many different locations would probably recover this initial investment over time. —

Whether a decontamination station is constructed on-site or is in the form of a trailer, the basic design components are the same. A discussion of these major components and their uses follow the illustrated diagram Figure X-1.

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Duct tape alone will not support the weight of the poly after exposure to the varying environmental conditions which occurs inside the work area. The sheets may be hung using a combination of nails and furring strips (small wood blocks), or adhesive and staples, and sealed with four-inch duct tape. Nails may cause some minor damage to the interior finish; however, it is usually more time efficient to touch up the nail holes than to repeatedly repair fallen barriers.

D. Light Fixtures

Light fixtures may have to be removed or detached and suspended (bailing wire works well) to gain access to asbestos-containing material. Before beginning this task, the electrical supply should be shut off, tagged and locked. The light fixtures should be wet-wiped before they are removed from the area. If it is not feasible to remove the fixtures, they should be wet-wiped and completely enclosed with poly.

STEP 6 - Locate and Secure the Electrical System

Amended water is typically used to saturate asbestos-containing sprayed-on material prior to removal. This creates a humid environment with damp to very wet and slippery floors. To eliminate the potential for a shock hazard, the electrical supply to the work area should be de-energized and locked out before removal operations begin. The following items need to be addressed before removal actually begins:

- Identify and de-energize 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. The breaker box can't be locked if it contains energized circuits for non-work areas; individual breakers may have to be locked out. Custodial personnel should be consulted about electrical distribution to other areas of an occupied building.
- Make provisions for supplying the work area with electricity from outside the work area which is equipped with a ground-fault-interrupt system.
- If the electrical supply cannot be disconnected, energized parts must be insulated or guarded from employee contact and any other conductive object.

STEP 7 - Securing the Work Area

The work area should be secured to prevent contamination from spreading beyond the work area. All entrances 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 poly covered walls to indicate the location of exits.

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A single entrance to be used for access and egress to the work area should be selected. Covering windows and all other doors not being used during abatement with a layer of poly before covering the walls provides a back-up layer of protection and saves time in installation because it reduces the number of edges of poly that must be cut and taped. A single entrance to be used for access and egress to the work area should be selected. This would most likely be the decontamination area which is discussed later in this section.

B. Floor

Six mil poly sheets should be used to cover the floor in the work area. Several sheets will need to be seamed together with spray adhesive and duct tape. To check the integrity of the seal, blue or red carpenter's chalk may be placed beneath the seam line. If a water leak occurs, the seam line will darken in color. Any leaks that occur should be promptly cleaned up. The poly floor sheets would be cut and peeled back to access the wet area. After mopping up the water and any contamination that leaked through, the area should be wet-wiped with clean rags. After the area dries, the peeled-back sheets are put back in place and sealed with duct tape. An additional "patch" sheet can be placed over this area and sealed with tape to provide extra protection.

After joining the sheets of poly together, the floor covering should be cut to the proper dimensions, allowing the poly to extend twenty-four inches up the wall, all the way around the room. The poly should be flush with the walls at each corner to prevent damage by foot traffic.

When the first layer of poly has been secured in place, the walls are covered with poly and a second layer should be layed on the floor 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 secured with three-inch duct tape.

Potential slippery spots may be encountered when covering stairs or ramps and care must be taken to provide traction for foot traffic. Wet poly is very slippery and can create serious tripping hazards. To provide better footing, masking tape or thin wood strips can be placed on top of the poly to provide rough surfaces in these areas.

C. Walls

After the first layer of polyethylene has covered the floors and stationary objects, multiple layers of 4 mil polyethylene are used to cover the walls. The lighter weight 4 mil is easier to hang and keep in place than the heavier 6 mil.

The sheets of 4 mil poly should be hung from the top of the wall a few inches below the ceiling and should extend across the floor area until it meets in the center of the area, where it is taped to form a single layer of material encasing the entire room except for the ceiling. Over lapping of the vertical sheets will be necessary; the seams should be sealed with adhesive duct tape.

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STEP 3 - Shut Down the Heating, Ventilating, and Air Conditioning System (HVAC)

The HVAC system supplying the work area should be shut down and isolated to prevent entrainment of asbestos dust throughout the building. To avoid inadvertent activation of the HVAC system while removal operations are in progress, the control panel should be tagged and locked. Personnel need to be warned not to activate any control panels. HVAC system balancing needs to be considered to avoid over pressurization in the occupied portions of buildings.

All vents and air ducts inside the work area should be covered and sealed with two layers of 6 mil polyethylene and duct tape. The first layer of polyethylene (poly) should be left in place until the area has passed final visual inspection and clearance air monitoring.

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 (see Disposal of Waste). If the filters are contaminated, the inside walls of the air ducts are probably also contaminated and the contractor should make efforts to clean or dispose of them.

STEP 4 - Clean/Remove Non-Stationary Items from the Work Area

Preparation for constructing negative - pressure enclosures, as required per 29 CFR 1926.58(g), should begin with the cleaning of all objects in the work area. The objects should first be vacuumed with a HEPA vacuum and cleaned with amended water, unless they are made of material that will be damaged by the wetting agent. Wiping with plain water is recommended in those cases where amended water will damage the object. Non-stationary items should be removed from the work area (e.g., desks, chairs, rugs and light fixtures) to ensure that these objects do not become contaminated with asbestos. Drapes should be removed for dry cleaning or disposal; caution should be advised to dry cleaning personnel. Carpets contaminated with debris or suspected of being contaminated should be disposed of as asbestos - containing waste.

Workers involved with the cleaning and removal should at least wear a half mask HEPA filter dual cartridge respirator and disposable clothing when initial preparation work is being carried out.

STEP 5 - Cover and Seal Stationary Items with Polyethylene

Before the asbestos removal work begins, objects that cannot be moved from the asbestos-contaminated work area should be HEPA vacuumed or wet-wiped and covered with a 6-mil-thick poly sheeting. It should be securely taped with duct tape or plastic tape to achieve an air-tight seal around the object and to insure they do not become contaminated during the removal project. Items not being removed may include large pieces of machinery, blackboards, water fountains, toilets, etc. Use of two layers of poly is a good recommended practice.

A specific outline of items to be covered and sealed is included here.

A. Windows and Doors

The edges of all the windows should be sealed with 3" wide high quality duct tape. After the edges have been taped, the windows should be covered and sealed with 6 mil poly and duct tape.

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PREPARING THE WORK AREA

The main purpose of properly preparing the work area (where asbestos is to be removed) prior to removal is to prevent exposure to airborne concentrations of asbestos fibers of both workers and building occupants. Airborne fibers which are generated by disturbance of asbestos-containing material may remain suspended in the air for long periods of time because of their small size and aerodynamic properties. These airborne asbestos fibers can migrate via air currents to other parts of the building.

Preparation of the work area before an asbestos abatement project begins serves the primary purpose of containing fibers which are released within the work area. Good preparation techniques serve to protect interior finishes such as hardwood floors or carpets from water damage and to reduce cleanup efforts. Preventing injury through appropriate safety practices is another major consideration in work area preparation (see section in Other Safety and Health Considerations).

Each project has unique requirements for effective preparation. For instance, the sequence of steps would probably be different for preparing a boiler room than preparing an area with asbestos material above a suspended ceiling. This may be attributed to the age of the building, the physical condition of materials, as well as HVAC system involvement. The following are general guidelines which can be modified to address specific problems encountered on an asbestos abatement project.

STEP 1 - Conduct Walkthrough Survey of the Work Area

The contractor, building owner, and architect/engineer should make a walkthrough survey to inventory and photograph any existing damages. Information gained can be used to plan for preparation steps and also to aid in preparation of realistic bid cost. Complete documentation of pre-existing conditions can benefit those involved if litigation should occur at a later date.

STEP 2 - Post Warning Signs

Warning signs that demarcate regulated work areas should be displayed at each location (entrances) where airborne concentrations of asbestos may be in excess of the 0.2 f/cc exposure limit. Signs should be positioned such that any person would notice the warning before entering the area and be able to take the proper necessary protective actions.

The warning signs are required to contain the following information: (1) that asbestos is a dangerous cancer and lung disease hazard, (2) that authorized personnel only are allowed in the work area, and (3) that respirators and protective clothing are required before entering the area. See 29CFR 1926.58(k) of the OSHA Construction Industry Standard for sign specifications. (Appendix A) These signs are available from most safety supply companies or asbestos abatement contractor suppliers.

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The main limitations of respirators are that they are not infallible. Even though they are designed to protect the respiratory system, they can break down or fail at any time, especially if not used properly. They also require a great deal of maintenance which is generally left up to the worker. This means many times the respirator probably isn't working at its fullest capacity. Finally, the respirator is limited by the filtering ability of the cartridge. Filtering mechanisms have not been designed to strain the smallest microscopic particles, so it must be assumed that an undetermined amount of contamination bypasses the respiratory protection.

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manufacturer's representative will often provide assistance in this area. It is also recommended that an industrial hygienist or other person familiar with such systems be retained for advice during initial set-up and until the job superintendent is comfortable with system operations.

The air-supplied mask chosen by the contractor is often one that contains a HEPA escape cartridge which permits the worker to disconnect from the air line in the event of a loss of air pressure or an emergency. While the protection factor drops when on the HEPA filter, the worker normally does not need the high protection of the airline when escaping from the work area.

Plastic caps or tape should be used to cover all exposed airline connections when not in use. This will keep asbestos debris from becoming caked in the quick disconnects. The airlines and manifolds will need to be cleaned completely at the end of the project. It is a good idea to keep the manifold draped with plastic during gross removal and clean-up. Also, coiling the clean air lines and sealing them in plastic bags to be opened inside the next work area is a good practice and saves time.

Thorough training of the asbestos abatement workers is necessary. This becomes even more important when airline respirators are used. Once workers become accustomed to the airline respirators, they usually find them much more comfortable than the cartridge respirators since a cool, fresh supply of air is continuously fed into the respirator. This keeps the facepiece from fogging and helps reduce the incidence of heat stress, if applicable.

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(3) Storage

Air exiting the purification unit should meet the Grade D requirements already discussed. If a high pressure supplied-air system (greater than about 200 psi) is used, the purified air may go directly into a high pressure storage tank or reservoir. A high pressure air line (usually a stainless steel, 1/4 to 1/2 inch inside diameter line) is run into the work area to a manifold and regulator. At this point, the regulator reduces the pressure to under 125 psi for service to the workers through low pressure air lines.

If a low pressure system (less than 200 psi) is used, the purified air will usually be fed directly to a manifold in the work area via low pressure (high volume) air line. At the manifold, several air lines will be run to the individual workers. To store air in the event of compressor shutdown, a check valve is installed between the filtration unit and the work area manifold. If the compressor shuts off, the check valve should open to provide air from a series of bottles (high pressure) containing grade D breathing air. The volume of air to provide adequate escape time will depend on the number of employees and time needed to evacuate the work area in an orderly manner. A reservoir of air for this purpose is required by OSHA (29 CFR 1910.134).

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(4) Delivery

Once the air has been compressed, purified, and an adequate reserve available for emergencies, it is ready for delivery to the asbestos abatement workers. Usually, large air lines from outside the work area are used to feed manifolds in the work area. Each manifold can usually accommodate 2-6 air lines. In this way, short air lines (about 50 feet) can be used, reducing the amount to be pulled about by the worker or tripped over by others. Each airline connects to a belt- or facepiece-mounted regulator which controls flow into the mask.

The amount of air actually needed will depend on many factors including the type of respirator, number of workers, and auxiliary equipment. Tight-fitting supplied-air masks must be supplied with a minimum of 4 cubic feet of air per minute (CFM). Loose-fitting supplied-air respirators must be provided with 6 CFM at a minimum. For each of these types of masks, the maximum recommended flowrate is 15 CFM. It should be noted that the use of vortex air cooling devices will require additional air flow according to the specifications of the vortex unit chosen.

Any air-line respirator chosen must be approved by NIOSH/MSHA (National Institute for Occupational Safety and Health and the Mine Safety and Health Administration). These agencies approve each air-line respirator as an entire unit, including facepiece, regulator, and airline. No unapproved respirators may be used at any time. The maximum airline length for any approved respirator may not exceed 300 feet; the maximum inlet pressure at the manifold cannot exceed 125 psi. Any alteration of the respirator or its subassemblies voids the approval. Accordingly, replacement parts must be supplied by the manufacturer for their respirators only.

Additional Information

The following items are provided merely as suggestions for work practices when using air-supplied respirator systems. Most importantly, the contractor should become fully knowledgeable on the use, limitations and maintenance of the system. The

air-driven machinery. Further, be sure to follow the manufacturer's operating instructions and service schedule.

The compressor should be located in a covered area with good ventilation. An area under a shade tree with a cool breeze is ideal, but the compressor should never be placed in an area with below freezing temperatures. The air intake should be located at least 8 feet above the ground and a coarse filter used as previously described. Gasoline should always be stored out of direct sunlight in a cool area, not accessible to visitors, etc.

(2) Purification

The second step in air processing is purification. While the compressor may remove some water through the condensate traps, additional moisture, odors, oil, hydrocarbons, heat, and carbon monoxide must be removed. Equipment for the purification process consists of a series of filters, adsorption columns, and sieves. This equipment is normally purchased as one unit at a cost of \$8,000-\$15,000 for a low pressure unit, and \$6,000-\$12,000 for a high pressure unit.

Purification equipment normally has an aftercooler air or water-cooled to remove heat, thereby cooling the air. Following the aftercooler, the air stream passes through one or more coalescing elements. A coalescing element causes aerosol droplets to join together (or coalesce) and form larger drops that impinge on the filtering surface and are too heavy to be re-entrained in the air stream. The coalescing element removes droplets of water and oil, as well as solid particles larger than about 10 micrometers in diameter through mechanical filtration.

Two adsorption canisters are usually located next in line to the coalescing element(s). The first adsorption canister consists of a column packed with a molecular sieve to remove water vapor. This canister also removes gaseous hydrocarbons, nitrogen oxides, sulfur compounds, and other odors. Following this canister is a column containing activated charcoal, which removes additional unpleasant odors and oil vapor. Each of the sorbent materials (molecular sieve and activated charcoal) will need periodic replacement according to the manufacturer's specifications.

The next step in the purification process is eliminating carbon monoxide through oxidation. In the presence of a catalyst, typically hopcalite, carbon monoxide will combine with oxygen to form carbon dioxide, a much less harmful gas. It should be noted that water destroys the catalyst. Therefore, the removal of water and water vapor before this stage of purification is extremely important.

Following the carbon monoxide catalyst, there is usually a mechanical filter to remove any particles larger than 0.5 micrometers in diameter. After the filter, there is usually a carbon monoxide monitor and alarm. This instrument measures the concentration of carbon monoxide in the supply air stream. The calibration procedure and frequency specified by the manufacturer should be followed (for example, the MSA CO monitor must be calibrated monthly). The carbon monoxide monitor should be equipped with a visual and audible alarm to alert the operator of a high carbon monoxide level in the supply air. Also, the filtration unit should have an air-powered horn to alert the operator of electrical power failure. The unit will continue to function; however, the carbon monoxide monitor and the aftercooling fan will not operate without electricity.

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Contractor supervisors should be aware of any other potential sources of toxic gases near the air intake. This would be especially important in industrial settings where gases are commonplace. Contaminants not listed in the specifications for Grade D air should not exceed one-tenth of the Threshold Limit Values (TLVs) for Chemical Substances in the Work Environment, adopted by the American Conference of Governmental Industrial Hygienists (ACGIH). A copy of this booklet may be obtained for a nominal charge from the ACGIH, 6500 Glenway Avenue, Bldg. D-7, Cincinnati, Ohio 45211-4438 (Phone: 513-661-7881).

AIR PROCESSING

A properly established type C supplied-air system does not simply pump air to workers; the air must also be processed. Along with air that enters the compressor, heat and water vapor are also processed. As the air is compressed, the temperature rises. When the compressed air drops back to normal ambient pressure, the temperature likewise returns to normal. Therefore, heat should be removed from the compressed air so that the air that reaches the worker inside the respirator is cool and comfortable.

Water vapor, when compressed, forms water droplets or condensation. If this water is not removed, it can build up in the air lines to the workers to the point where a solid "plug" of water is formed. This plug of water will quickly be forced into the respirator of the workers. It is quite likely that the workers will immediately discard the masks, or be startled by the sudden flood of water, potentially causing an accident (fall from a scaffold or ladder). Accordingly, the air processing equipment must be capable of removing moisture from the supply air.

There are four basic steps in establishing a type C supplied-air system.

These are:

- (1) compression
- (2) purification
- (3) storage
- (4) distribution

(1) Compression

Compression of air is necessary to store the air in a reduced space until needed. There are many different types of compressors available to perform this task. Some are oil-free using non-lubricated Teflon piston rings. More typical is the reciprocating multistage oil-lubricated compressor. Screw-type compressors and diaphragm compressors are also available. Compressors may be gasoline, diesel, or electric powered. In a reciprocating compressor, air is compressed in steps or stages. At each stage (or immediately following) there should be a condensate trap to allow water to be expelled. The compressor should have a high air temperature shutdown switch, an automatic start-stop pressure switch, and a low oil level shutdown switch. The choice of lubricating oil will depend on the individual make and model of the compressor. Usually, however, mineral oil or a high grade synthetic oil is used. The compressor should also have appropriate pressure gauges and safety valves.

When selecting a compressor (or renting), be sure the manufacturer is aware of its intended use. Some compressors deliberately add oil to the air stream for lubricating

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GRADE D BREATHING AIR REQUIREMENTS

Oxygen	19.5 - 23.5%
Carbon Monoxide (CO)	20 parts per million, maximum
Carbon Dioxide (CO ₂)	1000 parts per million, maximum
Condensed Hydrocarbons	5 milligrams per cubic meter, maximum
Objectionable Odors	None
Water Vapor	The CGA standard does not specifically establish a limit for moisture; however, a limit of 66 parts per million is necessary to assure proper function of CO scrubbing devices.

Normal air contains 20.9% oxygen. The oxygen content in breathing air should always fall between 19.5% and 23.5%. Normally, the oxygen content is only a consideration when purchasing bottled air which has been manufactured. Since the oxygen content of ambient air remains quite constant, and compressing the air does not alter the oxygen content, there is little concern that the asbestos abatement worker will be short of oxygen.

Perhaps the greatest concern when dealing with type C supplied-air systems is the generation or presence of carbon monoxide. This contaminant may be introduced into the breathing air through compressor malfunction or, more commonly, it may be drawn into the compressor intake. Carbon monoxide may be produced by the compressor if it overheats. The overheating causes the lubricating oil to break down with carbon monoxide being released. For this reason, high temperature alarms are often installed on compressors. OSHA requires that oil-lubricated compressors have a high-temperature or carbon monoxide alarm, or both. If only a high temperature alarm is used, the air from the compressor shall be frequently tested for carbon monoxide. The term "frequently" is not defined by OSHA, but a 1966 General Services Administration Specification for Breathing Air (BB-A-1034a) requires manual CO testing every 4 hours of use.

One alternative is to use an oil-free compressor to eliminate the chance of oil breakdown if the compressor overheats. However, oil-free compressors usually require more frequent servicing, and the synthetic materials used may release gaseous contaminants if the compressor overheats. (Note: The Canadian Standards Association has established a limit of 2 ppm in compressed breathing air for each of the following: trichlorotrifluoroethane, dichlorodifluoromethane, and chlorodifluoromethane.)

To avoid drawing carbon monoxide into the compressor directly, an extension intake flexible duct should be used to place the air intake at a remote location. The location chosen should be away from any combustion sources (i.e., vehicle exhausts, smokestacks, etc.). Frequently, the best location is 15 or 20 feet up in a tree, since it would be unlikely that a truck or car, lawnmower or other carbon monoxide producing vehicle could affect the supply air. Be sure to place a coarse filter (screen) over the air inlet to keep leaves, bugs, etc., from being drawn into the compressor.

ESTABLISHING A TYPE C SUPPLIED-AIR SYSTEM

Good practices generally require the use of type C supplied-air respirators on any asbestos removal project. If the assumption is made that 0.01 fibers per cubic centimeter (f/cc) will be the clearance level at the conclusion of a removal project, the workers performing the abatement work should not be exposed, inside the respirator, to concentrations of asbestos fibers any greater than this. The selection of appropriate respiratory protection now becomes greatly simplified. Using established protection factors (a ratio of the concentration outside the mask to that expected inside the mask), maximum anticipated fiber levels outside the respirator may be used to select the proper respiratory protection to reduce the concentration inside the mask to 0.01 f/cc or below.

As a rule of thumb, air-purifying respirators are usually adequate protection for the worker during work area preparation and final wipe-down following gross clean-up. Good practices require the use of type C supplied-air respirators once gross removal begins through gross clean-up of the work area.

A type C supplied-air system normally consists of a compressor, air delivery lines, air cleaning apparatus, a reserve air supply, and NIOSH-approved masks. Instead of a compressor, the source of compressed air may also be a bank of high pressure air cylinders, in which case, an air cleaning apparatus is not necessary. At a minimum, a type C system should provide the following:

- o Continuous and sufficient supply of Grade D air
- o NIOSH-approved respirators and supply hoses
- o Adequate reserve or escape time
- o Breathing air temperature control
- o Continuous monitor and alarm for carbon monoxide (CO)

GRADE D AIR

Grade D Air is the minimum quality for routine use in supplied-air (or self-contained) breathing equipment, as used in fire fighting, general industry, and asbestos abatement projects where supplied-air respirators are in use. There are other grades of air purity including Grade E (minimum requirements for sports diving to 125 feet) and Grade H. Each of these grades (E and H) are more stringent than Grade D specifications. The Grade D air specifications were established by the Compressed Gas Association, Inc. of New York and incorporated into the OSHA Respirator Standard (29 CFR 1910.134) by reference. The specifications themselves are contained in the Compressed Gas Association (CGA) Pamphlet G-7, entitled, "Compressed Air for Human Respiration." These specifications are discussed briefly below. Asbestos abatement contractors performing work in Canada should be aware that breathing air must meet considerably more stringent standards as described in the Compressed Breathing Air Standard Z180.1-1978. This may be obtained from the Canadian Standards Association in Rexdale, Ontario, Canada.

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11. Other protective equipment such as hard hats and safety glasses (if a half-face respirator is used) are put on.

One person should remain outside the work area at all times. It should be his/her responsibility to ensure that each person entering the work area has the proper protective clothing and to log them in and out.

Once inside the work area, no employees, or others, should be permitted to leave without going through the decontamination sequence unless it is an extreme emergency. A common problem is employees "stepping out" for a cigarette or supervisors "stepping in" the work area to deliver a message or a piece of equipment. These activities defeat the purpose of the protective equipment and the decontamination sequence.

TAKING PROTECTIVE CLOTHING OFF

Whenever an employee or other person leaves a work area for any reason, he/she must go through the decontamination sequence. This sequence should include the following steps:

1. Clean reusable protective equipment such as boots/shoes, safety glasses, hard hats, etc.
2. Remove all protective garments and equipment (except respirators) in an area immediately outside the shower on the contaminated side. An area should be designated for this purpose and kept as free as practicable of asbestos-contaminated material. All disposable clothing should be placed in plastic bags inside a drum and labelled as asbestos-containing waste.
3. Proceed to the shower still wearing respirator. While showering, be sure to soak the respirator cartridges if not using supplied air. The cartridges may then be discarded in a plastic bag located at the shower.
4. Proceed to the clean room, dry off, dress in street clothes, and disinfect, clean, and inspect respirator. If air supply is not being used, new cartridges should be placed in the respirator.

OTHER PERSONAL PROTECTIVE EQUIPMENT

Additional protective equipment may be necessary depending on the specific project. The most common other protective equipment will include eye protection. Goggles or safety glasses (with side shields) are often adequate. Hard hats, safety shoes, and hearing protection may also be necessary on certain projects.

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A common problem on asbestos abatement projects is a failure by contractors to purchase enough coveralls for the project. Each worker must use a new coverall (and foot and head covering if not attached) each time he/she enters the work area. Assuming two breaks and a lunch period, four coveralls will be needed each day by each worker. Additional coveralls are usually needed for authorized visitors (architect, industrial hygienist, etc.) and to replace some that are torn to the point of being unusable. As a rule of thumb, the contractor may estimate the number of suits needed on a project by the following formula:

$$5 \times \text{no. of workers} \times \text{project duration (days)} = \text{number of coveralls needed.}$$

As an example, a project lasting 48 days using a crew of 8 workers and one job foreman will need the following number of coveralls (estimated).

$$5 \times 9 \text{ workers} \times 48 \text{ days} = 2160 \text{ coveralls.}$$

Accordingly, the contractor should order 90 cases (24 per case) of coveralls for the project. The prudent contractor would purchase 100 cases to allow for sufficient surplus. When purchasing coveralls, large and extra large sizes should be purchased. These can always be made to fit smaller employees.

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PUTTING PROTECTIVE CLOTHING ON

Protective clothing is put on in the clean room of the decontamination unit before entering the work area. The following sequence should be used.

1. All street clothes, including undergarments, are removed and stored in a clean, convenient location. Bins or lockers work well for this. It is usually wise to have a lockbox or other means to protect valuables. This will discourage employees from bringing wallets, rings, keys, etc., into the work area.
2. The nylon swim suit is put on.
3. The disposable coveralls are put on.
4. If separate disposable foot coverings are used, these are put on.
5. Ankles are taped to take up slack in the suits and reduce the chance of tripping. (Tape pants over foot coverings, if separate.)
6. The respiratory equipment is inspected, put on, and fit checked.
7. The hood or head covering is put on over the respirator head straps.
8. Worker passes through airlocks and shower to contaminated equipment room.
9. Deck shoes are put on (or safety shoes/boots, as required).
10. Gloves are put on (cotton gloves are usually worn although leather gloves should be used for handling metal lathe). The sleeves are taped over the gloves using duct tape.

PROTECTING THE WORKER: CLOTHING

It is first important to understand why protective clothing is worn during asbestos abatement work: the primary reason is to keep gross amounts of asbestos-containing debris off the body, hair, etc. The use of protective clothing and showers will minimize the chance of bringing asbestos out of the work area and into the home. Protective clothing will also minimize the chance of rashes and discomfort caused by the material being removed. In addition to the asbestos, frequently the material being removed contain mineral wool, fiberglass, and binders such as cement. Each of these may be irritating to the skin. Continued direct contact with asbestos has also been shown to cause "asbestos warts". These warts often take months to heal and occur more frequently if asbestos is trapped beneath a watchband, or in other ways kept in close contact with the skin.

Protective clothing for asbestos abatement projects usually consists of disposable coveralls, foot covering and head covering. The foot and head covering should be attached to the coveralls. This eliminates the need to tape openings between garments, etc. Tight fitting bathing suits may sometimes be worn beneath the coveralls. Nylon suits work well and can be cleaned easily during showering. Gloves should be worn when inside the work area. Any article that cannot be decontaminated should remain on the dirty equipment room side of the enclosure.

Protective clothing does not include street clothes, T-shirts, blue jeans, sweat bands, kneepads and socks. If any of these items are used inside the work area, they should remain there until the job is completed and be disposed of as asbestos-contaminated waste. Jewelry such as rings and ID bracelets should not be worn in the work area.

Other protective clothing/items such as hard hats and safety shoes/boots should remain in the work area for the duration of the project. Upon project completion, these items can be cleaned, placed in a plastic bag, labelled as containing asbestos, and taken to the next project. If safety shoes/boots are not used, it is wise to have workers wear rubber soled, slip-on deck shoes. These remain in the work area and are disposed of at the end of the project as asbestos-containing waste. These deck shoes are usually of canvas construction and are inexpensive (about \$10.00 per pair). It is a good idea to have each worker mark their name on shoes and hard hat with permanent ink.

To summarize, listed below is a list of items normally worn by asbestos abatement employees:

- Disposable coveralls, foot covering, and disposable head covering
- Nylon swim suit (tight fitting)
- Slip-on deck shoes with non-skid rubber soles
- Hard hat (as required)
- Gloves (cotton is practical)
- Eye protection (not needed if full facepiece respirators are used)

The disposable coveralls, foot, and head coverings are available from many sources and several materials. Coveralls, with foot and head covering attached usually cost about \$3.00 each when purchased in quantity. Separately, the coveralls cost approximately \$2.00, head covering about \$0.35, and foot covering about \$0.50 per pair. It is important to realize that many "bargain" prices may not be a bargain at all. The less expensive coveralls often use less material. Accordingly, coveralls marked "XL" may be too small for many workers. Be sure to check the construction of the coveralls as well. Double stitching on seams will last longer, but cost more.

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which contains the test substance in the air. The airborne concentration of the substance is measured outside the respirator and inside the respirator while the employee mimics several typical work related activities. The specific degree of protection — protection factor — can be determined for the wearer with the specific respirator worn.

Quantitative fit-testing is usually performed in a laboratory; however, portable fit-testing units are available and some companies offer on-site testing.

Other factors that may alter respirator fit may include, but are not limited to, false teeth, a weight loss or gain, or surgery.

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QUALITATIVE FIT-TESTING

During fit-testing, the respirator straps must be properly adjusted, in accordance with the manufacturers direction, and should be as comfortable as possible. Over tightening the straps will sometimes reduce facepiece leakage, but the wearer may be unable to tolerate the respirator for any length of time. The facepiece should not press into the face and shut off blood circulation or cause major discomfort. At the time of respirator selection, a visual inspection of the fit should always be made by a second person.

The actual qualitative fit-test method chosen is at the discretion of the employer as long as it is one of the three specified in Appendix C of the OSHA Asbestos Standards (29 CFR 1910.1001 or 29 CFR 1926.58). The procedures used must follow those in this appendix whether irritant smoke, isoamyl acetate, or saccharin is chosen as the test agent. The irritant smoke test is summarized below as it is the only test that produces an involuntary response if the proper fit is not achieved.

Irritant Smoke Test

If the previous checks have been successful, the irritant smoke test may be administered. It can be used for both air-purifying and supplied-air respirators. However, an air-purifying respirator must have high efficiency filters. The test substance is an irritant smoke (stannic chloride or titanium tetrachloride). Sealed glass and plastic tubes with substances to generate this smoke are available from safety supply companies. When the tube ends are broken and air passes through them with a squeeze bulb, a dense irritating smoke is emitted.

For the test, the respirator wearer enters a test enclosure, a clear suspended plastic bag is sufficient, and the irritant smoke is sprayed/squeezed into a small hole punched in the bag near the respirator wearer's head. A number of exercises are performed that would simulate activities normally encountered in a work situation (such as, talking, head moving, jogging in place, etc.). If the wearer detects the irritant smoke inside the respirator, it indicates a defective fit; the respirator fails this test. The advantage to this test is that the wearer usually reacts involuntarily to leakage by coughing or sneezing. The likelihood of pretending to pass this test is low.

NOTE: This test must be performed with caution because the irritant smoke is highly irritating to the eyes, skin, and mucous membranes. When testing a half-face mask respirator, the eyes must be kept tightly closed.

QUANTITATIVE FIT-TESTING

Quantitative fit-testing requires a test substance which can be generated into the air, specialized equipment to measure the airborne concentration of the substance, and a trained tester. A sodium chloride solution, corn oil or mineral oil is usually used to perform this test. The person to be tested puts on the respirator and enters a chamber

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protect you unless the air you breath passes through the filter or canister, or unless all of the air comes from the supply system. If the face seal is not tight or the connections are loose you may think you are breathing through the purifying system, but may actually be breathing around it.

You may have to try several different respirators before you find one that fits properly. For any tight-fitting respirator, beards and bushy sideburns may have to be shorn. Respirator facepieces will not seal over them. Similarly, gum and tobacco chewing cannot be permitted since excess facial movement can break the faceseal. If you wear prescription glasses, you must wear a respiratory facepiece which will accommodate the glasses. Contact lenses should not be worn while wearing a respirator. A properly fitted respirator will stretch the skin at the temples slightly so that the contact lens might easily pop out.

The OSHA asbestos standards (29 CFR 1910.1001 and 1926.58) and the OSHA respirator standard (29 CFR 1910.134) require that the fit of respirators be determined when they are issued and that the fit be checked each time the respirator is worn.

There are two major categories of fit-testing, qualitative (pass/fail) and quantitative (measures levels within the mask). Only those tests applicable to asbestos work are discussed below.

RESPIRATOR FIT CHECKS

Once the respirator has been selected and no visual leaks are evident a negative pressure check and positive pressure check are performed by the wearer. These simple procedures are described below.

a. Negative Pressure Check

For this fit-check the wearer closes off the inlet of the filters or cartridges by covering them with the palms of the hands or by squeezing the breathing tube so that air cannot pass through, inhales so that the facepiece collapses slightly, and holds his/her breath for about 10 seconds. If the facepiece remains slightly collapsed and no inward leakage of air is detected, the respirator passes the check. This check can only be used on respirators with tight fitting facepieces. Its potential drawback is that hand pressure can modify the facepiece seal and cause false results.

b. Positive Pressure Check

This fit-check is similar in principle to the negative pressure fit-check. It is conducted by closing off the exhalation valve of the respirator and gently exhaling into the facepiece. The respirator fit is considered passing if positive pressure can be built up inside the facepiece without evidence of outward air leakage around the facepiece.

If the respirator selected fails to pass these simple fit-checks, the fit-testing should not proceed further. Instead, another size or another brand should be donned and these checks repeated. Alternatively, it may only be necessary to adjust the straps on the respirator and repeat the checks. Once the wearer has successfully passed the negative and positive pressure fit-checks, the actual fit-test may be conducted. The OSHA standards permit qualitative fit-testing for half-mask air-purifying respirators.

D. Self-contained Breathing Apparatus (SCBA)

1. Consult manufacturer's literature

REPAIR

At some point any respirator will need replacement parts or some other repair. The law requires that the person who repairs respirators be trained and qualified. It is important to realize that respirator parts from different manufacturers are not interchangeable. NIOSH approval is invalidated if parts are substituted.

RESPIRATOR STORAGE

Proper storage is very important. The law requires that respirators be protected from dust, sunlight, heat, extreme cold, excessive moisture, and damaging or contaminating chemicals. When not in use, the respirator should be placed in a closed plastic bag, and stored in a clean, convenient, sanitary location.

SURVEILLANCE OF WORKING CONDITIONS

The employer must provide adequate surveillance of the employee's working conditions to be certain the respirator selected provides adequate protection. In the case of asbestos abatement, this includes a determination if other hazardous airborne contaminants might be encountered for which the respirator chosen is not adequate. Air monitoring to estimate the asbestos exposure provides the needed information to determine if the respirator chosen affords sufficient protection to the individual.

RESPIRATOR PROGRAM EVALUATION AND RECORDKEEPING

The respirator program shall be evaluated at least annually with program adjustments, as appropriate, made to reflect air sampling or other evaluation results. Compliance to the aforementioned points of the program should be reviewed; respirator selection, purchase of approved equipment, medical screening of employees, fit testing, issuance of equipment and associated maintenance, storage, repair and inspection, appropriate surveillance of work area conditions.

Attention should be given to proper recordkeeping. Records which should be kept include: names of employees trained in respirator use, documentation of the care and maintenance of respirators, medical reports of each respirator user, possible airborne concentrations of asbestos fibers during work, and any problems encountered during projects with regards to respiratory equipment. A checklist for self-evaluation of a respiratory protection program is included at the conclusion of this chapter.

FITTING RESPIRATORY PROTECTIVE EQUIPMENT

Only tight-fitting respirators that have been selected for contaminants and conditions to which you are potentially exposed, must be fit-tested. A respirator will not

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4. Excessively worn serrations of the head harness which might allow the facepiece to slip

C. Inhalation valve, exhalation valve, should be checked for:

1. Detergent residue, dust particles or dirt on valve seat.
2. Cracks, tears or distortion in the valve material or valve seat.
3. Missing or defective valve cover

D. Filter elements should be checked for:

1. Proper filter for the hazard
2. Approval designation (TC . . . ID # . . .)
3. Missing or worn gaskets
4. Worn threads
5. Cracks or dents in filter housing

II. Powered Air Purifying Respirators

- A. Check facepiece, headstraps, valve and breathing tube, as for regular air purifying respirators.

B. Hood or helmet, if applicable -- check for:

1. Headgear suspension (adjust properly for wearer)
2. Cracks or breaks in faceshield (replace faceshield)

III. Supplied Air Respirators

Facepiece, headstrap, and valves should be checked as specified above. In addition, the following checks should be performed:

A. Breathing tube should be checked for:

1. Cracks
2. Missing or loose hose clamps
3. Broken or missing connectors

B. Hood, helmet or suit should be checked for:

1. Headgear suspension
2. Cracks or breaks in faceshield
3. Rips and torn seams

C. Air supply systems should be checked for:

1. Breaks or kinks in air supply hoses and end fitting attachments
2. Tightness of connections
3. Proper setting of regulators and valves (consult manufacturer's recommendations)
4. Correct operation of air purifying elements and carbon monoxide or high-temperature alarms

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EMPLOYER TRAINING PROGRAM

Each employee designated to wear a respirator must receive adequate training. The training session (initial and periodic training) should be conducted by a qualified individual to ensure that employees understand the limitations, use, and maintenance of respiratory equipment.

RESPIRATOR FITTING

One of the most important elements of an effective respirator program is fit. The OSHA Asbestos Standards (29 CFR 1910.1001 and 1926.58) and the OSHA respirator standard (29 CFR 1910.134) require that the fit of respirators be determined when the respirator is issued and every six months thereafter for all negative pressure respirators. Procedures for fit-testing should be addressed in the written respirator program. A discussion of fit-testing is included elsewhere in this section.

CLEANING AND DISINFECTION OF RESPIRATORS

Whenever possible, a respirator should be reserved for the exclusive use of a single individual. Following each use, the respirator should be cleaned and disinfected. The following procedures can be used to clean a respirator:

- Wash with a detergent or a detergent/disinfectant combination, in warm water using a brush.
- Rinse in clean water, or rinse once with a disinfectant and once with clean water. The clean water rinse is particularly important because traces of detergent or disinfectant left on the mask can cause skin irritation and/or damage respirator components.
- Air dry on the rack or hang; position the respirator so that the facepiece rubber will not dry misshapened.

ROUTINE INSPECTION OF RESPIRATORS

Inspection of the respirator is an important, routine task. It should be done before and after each use. The following items should be checked, at a minimum.

- I. Air-Purifying Respirators (half-mask and full facepiece)
 - A. Rubber facepiece should be checked for:
 1. Excessive dirt
 2. Cracks, tears, or holes
 3. Distortion from improper storage
 4. Cracked, scratched or loose fitting lens
 5. Broken or missing mounting clips
 - B. Headstraps should be checked for:
 1. Breaks or tears
 2. Loss of elasticity
 3. Broken or malfunctioning buckles or attachments

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ESTABLISHING A POLICY

Every employer should prepare a clear concise policy regarding the use of respirators by their employees when performing asbestos abatement activities. This policy should serve as the guiding principal for the preparation, implementation, and enforcement of an effective respiratory protection program.

DESIGNATION OF A PROGRAM ADMINISTRATOR

A program administrator must be designated by name. This person is responsible for implementation of, and adherence to, the provisions of the respiratory protection program. It is usually a good idea to also designate a person who is responsible for enforcement of the procedures at each job site. Procedures should also be outlined for enforcement of the program. Enforcement procedures and the development of the program as a whole should be done in conjunction with and input from the employees and/or their representatives.

SELECTION AND USE OF RESPIRATORY PROTECTION EQUIPMENT

Respirators used shall be selected from those approved by the Mine Safety and Health Administration (MSHA) or the National Institute for Occupational Safety and Health (NIOSH) for use in atmospheres containing asbestos fibers. A NIOSH-approved respirator contains the following: an assigned identification number associated with each unit; a label identifying the type of hazard the respirator is designed to protect against; additional information on the label which indicates limitations and identifies the component parts approved for use with the basic unit.

Although some single-use disposable dust masks were at one time "approved" by NIOSH for use with asbestos, they should not be used during asbestos abatement projects. NIOSH has stated that these respirators do not provide adequate protection against asbestos. As a rule of thumb, negative pressure, air-purifying respirators with HEPA filters may be used during glovebag procedures.

MEDICAL APPROVAL

Only those individuals who are medically capable to wear respiratory protective equipment shall be issued a respirator. Initially, before being issued one, an employee will receive pertinent tests to evaluate medical and physical conditions, and annually thereafter. Medical tests to be conducted by a physician often include: pulmonary function tests, a chest x-ray (if a physician deems it necessary), electrocardiogram, and any other tests needed for proper evaluation by a physician. A medical history in the form of a questionnaire is collected as well for each individual. Other factors to be considered by a physician may include: emphysema, asthma, chronic bronchitis, heart disease, anemia, hemophilia, poor eyesight, poor hearing, hernia, lack of finger or hand usage, epileptic seizures, and other factors which might inhibit the ability of an employee to wear respiratory equipment.

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RESPIRATORY PROTECTION PROGRAM

Any employer who requires or permits employees to wear a respirator must have a written respiratory protection program. This is required by OSHA in both of their asbestos standards and their respiratory protection standard (29 CFR 1910.134). The written respirator program establishes standard operating procedures concerning the use and maintenance of respiratory equipment. In addition to having such a written program, the employer must also be able to demonstrate that the program is enforced and updated as necessary.

The OSHA regulations spell out just what must be included in a written program. Below, these items are discussed with special emphasis on applications to work performed by asbestos abatement personnel.

An effective respirator program as adapted from A Guide to Respiratory Protection for the Asbestos Abatement Industry, (U.S.EPA/NIOSH publication, EPA-560-PTS-86-001 September 1986) should include:

1. A written statement of company policy, including assignment of individual responsibility, accountability, and authority for required activities of the respiratory protection program.
2. Written standard operating procedures governing the selection and use of respirators.
3. Respirator selection (from NIOSH/MSHA approved and certified models) on the basis of hazards to which the worker is exposed.
4. Medical examinations of workers to determine whether or not they may be assigned an activity where negative pressure respiratory protection is required.
5. Employee training in the proper use and limitations of respirators (as well as a way to evaluate the skill and knowledge obtained by the worker through training).
6. Respirator fit testing.
7. Regular cleaning and disinfecting of respirators.
8. Routine inspection of respirators during cleaning, and at least once a month and after each use for those respirators designated for emergency use.
9. Storage of respirators in convenient, clean, and sanitary locations.
10. Surveillance of work area conditions and degree of employee exposure (e.g., through air monitoring).
11. Regular inspection and evaluation of the continued effectiveness of the program.

All of the above items are required by OSHA if employees wear respirators during work.

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RECOMMENDED RESPIRATOR SELECTION FOR PROTECTION AGAINST ASBESTOS

<u>RESPIRATOR SELECTION</u>	<u>OSHA PF</u>	<u>NIOSH PF¹</u>	<u>MAXIMUM USE CONCENTRATION²</u>
Half Mask Air-Purifying With HEPA Filters	10	10	0.1 f/cc
Full Facepiece Air-Purifying With HEPA Filters	50	50	0.5 f/cc
Powered Air-Purifying (PAPR), Loose-Fitting Helmet or Hood, HEPA Filter	100	25	0.25 f/cc
Powered Air-Purifying (PAPR), Full Facepiece, HEPA Filter	100	50	0.5 f/cc
Supplied Air, Continuous Flow, Loose-Fitting Helmet or Hood	100	25	0.25 f/cc
Supplied Air, Continuous Flow, Full Facepiece + HEPA Escape	100	50	0.5 f/cc
Full Facepiece Supplied Air, Pressure Demand + HEPA Escape	1,000	2,000	10 f/cc
Full Facepiece Supplied Air, Pressure Demand, with Aux. SCBA, Pressure Demand or Continuous Flow	> 1,000	10,000	> 10 f/cc

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Notes

1. These protection factors represent the most current state-of-the-art practice.
2. This value represents the maximum fiber concentration outside the respirator to maintain exposure inside the respirator below 0.01 fibers/cc. (It was calculated using the more conservative PF value between OSHA & NIOSH, assuming concentration inside the mask = 0.01f/cc.)

PROTECTION FACTORS

Respirators offer varying degrees of protection against asbestos fibers. The key to understanding the difference between types of respirators (air-purifying, powered air-purifying, air-supplied) is the amount of protection afforded the wearer. To compare these, one must understand the concept of a protection factor (PF).

A protection factor is defined as the concentration of a contaminant measured outside the mask divided by the concentration you would expect to find inside the mask. This simple formula is illustrated below.

$$\text{Protection Factor (PF)} = \frac{\text{Conc. Outside mask}}{\text{Conc. Inside mask}}$$

The protection factor depends greatly on the fit of the mask to the wearer's face. Accordingly, the protection offered by any one respirator will be different for each individual person. Further, the protection constantly changes depending upon the worker's activities and even shaving habits. When a worker laughs or coughs inside a respirator, the protection factor will decrease since the mask will not "fit" as well during laughing or coughing. Similarly, the worker who forgot to shave one morning will not receive as much protection that day since the mask will not fit as well to the face. The importance of properly fitting the mask should now be obvious.

It is virtually impossible to measure the concentration inside the mask (where the worker is breathing) for each worker, all the time, during the various activities he or she may be conducting. Accordingly, protection factors, based on extensive research, have been developed for different categories of respirators. Using these protection factors, it is easy to determine what type of respirator is appropriate to maintain the concentration of asbestos inside the mask below a certain level. (A level of 0.01 fibers per cubic centimeter (f/cc) is sometimes cited as the maximum desired level inside the mask.) Using established protection factors, the employer may select from the following table the appropriate respirator to maintain the concentration inside the respirator below 0.01 f/cc. It should be noted that the protection factors for powered-air purifying respirators are estimated on the most recent data available.

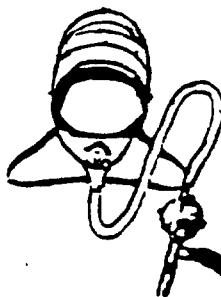
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Air purifying respirators remove limited concentrations of air contaminants from the breathing air, but do nothing to improve (or change) the oxygen content and where air contaminants do not exceed the specified range of the respirator and cartridge. Often, however, this is adequate protection when prepping the asbestos abatement work area, performing final clean-up (wipe-downs), or during glovebag removal projects. But during gross removal and gross clean-up, a different category of respirator is used to provide greater protection for the worker: the supplied-air respirator.

Supplied-Air Respirators

These respirators supply uncontaminated, breathing air from a source independent of the surrounding atmosphere. Air is delivered to the facepiece through an airline (a hose). You will often hear these respirators referred to as "airline or Type C respirators". Because of the importance and complexity of supplied-air respirators, the entire next section of this notebook is devoted to the topic of "Type C" supplied-air systems.

The supplied-air respirator, such as the one pictured here, is usually used for gross removal and clean-up on asbestos abatement projects.



Another type of respiratory protection sometimes used on asbestos abatement projects by inspectors is the self-contained breathing apparatus or "SCBA". The SCBA is a system that permits the user to carry a source of breathable air, usually in a compressed air cylinder worn on the back. Although SCBA respirators provide the highest level of protection, a significant drawback is they usually only provide 30 minutes to one hour of breathing air. Considering the time necessary to decontaminate, this only permits the individual to be in the work area for a brief period.

The SCBA provides the highest degree of protection, but is not very practical for asbestos abatement projects.



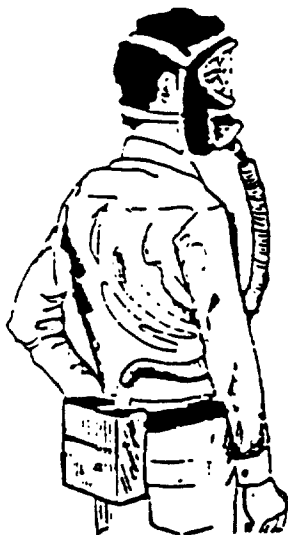
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The full-face air-purifying respirator provides greater protection than the half-face mask.

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A special subcategory of an air-purifying respirator is the Powered Air Purifying Respirator (PAPR) type. It uses the same types of cartridges and filters as regular air purifying respirators to clean the air. PAPR's, however, are positive-pressure devices which employ a portable, rechargeable battery pack and blower to force contaminated air through a filter or cartridge, where it is cleaned and supplied to the wearer's breathing zone. PAPR's are available in both tight-fitting and loose-fitting styles. Because the air is being drawn from the immediate work area, they too offer no protection against oxygen deficiency. An advantage of using a powered air-purifying respirator is that it supplies air at a positive pressure within the facepiece, helmet, or hood so that any leak is usually outward.



This person is wearing one of several powered air-purifying respirators to provide protection against asbestos fibers.

CATEGORIES OF RESPIRATORS

There are two broad categories of respirators. These are air-purifying and supplied-air respirators. In each category there are many different types of respirators (i.e., powered air-purifying, gas masks, pressure demand supplied-air respirators, etc.). Many of the respirators available for use, however, are not appropriate for protection against asbestos. For the most part, these will not be discussed.

Air-Purifying Respirators

These respirators remove the hazardous contaminant from the breathing air before it is inhaled. They consist of a soft, rubber or synthetic facepiece and replaceable filters or cartridges. Two major subcategories of air-purifying respirators are the mechanical filter type and the chemical cartridge type. The mechanical filter variety is designed to protect against particulate contaminants such as asbestos. The chemical cartridge type protects against gaseous contaminants such as solvent vapors. Each respirator assembly is approved for a particular contaminant. Care must be taken in choosing the appropriate unit. High efficiency particulate air (HEPA) filters designed for asbestos are typically purple or magenta in color. These filters will remove 99.97 percent of particles 0.3 micrometers or greater in diameter.

Air-purifying respirators are further categorized based on their degree of face coverage. The half-mask respirator covers half the face -- from the bridge of the nose to under the chin. A full-face respirator covers the face from the forehead to under the chin. The most extensive coverage provides a better fit and a higher degree of protection. Air-purifying respirators depend upon breathing action to draw atmospheric air through the respirator filter or cartridge where it is decontaminated. Hence, they are referred to as "negative pressure" respirators.

NOT THIS



Single use respirators such as this should not be used to protect against asbestos fibers.

BUT THIS

The half-face air-purifying respirator usually has two filter cartridges.



PERMISSIBLE CHEMICAL CARTRIDGE RESPIRATOR FOR ORGANIC VAPORS, DUSTS, FUMES, MISTS AND RADIONUCLIDES MINE SAFETY AND HEALTH ADMINISTRATION NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH	
MSHA	NIOSH
APPROVAL NO. TC-23C-243	APPROVAL NO. TC-21C-135
ISSUED TO	ISSUED TO
LIMITATIONS	LIMITATIONS
Approved for respiratory protection against not more than 1 000 parts per million organic vapors by volume, dusts, fumes, and mists having a time weighted average less than 0.05 milligram per cubic meter, asbestos containing dusts and mists and radionuclides. Do not wear for protection against organic vapors with poor warning properties or those which generate high heats of reaction with sorbent material in the cartridge. Maximum use concentration will be lowest than 1 000 parts per million organic vapors where that concentration produces atmospheres immediately dangerous to life or health. Not for use in atmospheres containing less than 19.5 percent oxygen. Not for use in atmospheres immediately dangerous to life or health. CAUTION In making renewals or repairs, parts identical with those furnished by the manufacturer under the pertinent approval shall be maintained. Follow the manufacturer's instructions for changing cartridges. This respirator shall be selected, fitted, used, and maintained in accordance with the Mine Safety and Health Administration, Occupational Safety and Health Administration, and other applicable regulations.	Approved for respiratory protection against dusts, fumes and mists having a time weighted average less than 0.05 milligram per cubic meter, asbestos containing dusts and mists and radionuclides. Not for use in atmospheres containing less than 19.5 percent oxygen. Not for use in atmospheres immediately dangerous to life or health. CAUTION In making renewals or repairs, parts identical with those furnished by the manufacturer under the pertinent approval shall be maintained. Follow the manufacturer's instructions for changing cartridges. This respirator shall be selected, fitted, used, and maintained in accordance with the Mine Safety and Health Administration, Occupational Safety and Health Administration, and other applicable regulations.
MSHA-NIOSH Approval TC-23C-243 March 10, 1983 Issued to The approved half mask facepiece respirator assembly for organic vapors, dust, fumes, mists and radionuclides consists of the following parts: 7-201-2, or 7-201-3 facepiece and 461973 (TC-23C-243) cartridges.	MSHA-NIOSH Approval TC-21C-135 June 29, 1983 Issued to The approved half mask facepiece respirator assembly for dusts, fumes, mists and radionuclides consists of the following parts: 449703, 7-201-1, or 7-201-3 facepiece and 459322 or 463312 (TC-21C-135) filters. The approved half mask facepiece with belt-mounted filter respirator assembly for dusts, fumes, mists and radionuclides consists of the following parts: 7-202-1, 7-202-2, or 7-202-3 facepiece, breathing tube and plenum assembly and 459322 or 463312 (TC-21C-135) filters.

FIGURE III-1 NIOSH Approval Labels, such as these, should accompany the respirator when purchased.

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RESPIRATORY HAZARDS

Respiratory hazards are generally divided into two categories; toxic contaminants and oxygen deficiency. Generally, asbestos abatement projects do not pose oxygen deficiency hazards. However, since there may be rare projects and circumstances where it can be a problem, oxygen deficiency must always be considered. For example, there could be an oxygen deficiency problem while performing abatement in steam tunnels, mechanical chases or boilers. Failing to consider oxygen deficiency could result in a fatality on any project.

Toxic contaminants are a more common category of respiratory hazards encountered on abatement projects. These toxic contaminants are generally divided into three categories: particulates, gaseous materials, or vapors (or a combination of two or all of the above). Asbestos fibers are an example of the particulate category, carbon monoxide is an example of the gaseous category, and an epoxy encapsulant is an example of a harmful (organic) vapor. It is possible to have all of these hazardous substances, as well as others in a work area at the same time.

The control of respiratory hazards often involves three steps:

- Assessing the hazards
- Reducing or eliminating the hazards
- Providing respiratory protective equipment

The asbestos detection and control industry is actually based on these first two steps. Buildings and other structures are inspected or surveyed to assess potential asbestos hazards. When a potential asbestos hazard exists, a contractor is called upon to reduce or eliminate the hazard through removal, encapsulation, or enclosure of the material. Thus, the third step, respirators, can be avoided to protect the building occupants, custodial, and maintenance personnel.

THE SELECTION OF APPROPRIATE RESPIRATORY EQUIPMENT

Respirators are commonly used to help protect against inhalation hazards. However, a respiratory protection program is not simply donning a respirator and expecting to be adequately protected.

The selection of appropriate respiratory equipment generally involves three steps:

1. Identifying the hazards;
2. Evaluating the hazards;
3. Providing proper respiratory protective equipment to suit the conditions and the individual.

The respirator selected and the respiratory program established must conform to Occupational Safety and Health Administration (OSHA) standards and guidelines published by respiratory manufacturers. The OSHA respirator standard (29 CFR 1910.134) requires that only approved respirators be used. They must be approved for protection specifically against asbestos fibers.

The National Institute for Occupational Safety and Health (NIOSH) is the official testing and approval agency for respirators. If the entire respirator assembly including cartridges, filters, and hoses, pass the NIOSH test, then they issue a NIOSH approval number. The specific number is preceded by the letters "TC", which indicates the respirator assembly was "Tested and Certified".

PROTECTING THE WORKER RESPIRATORS AND PROTECTIVE CLOTHING

INTRODUCTION

When asbestos-containing materials are disturbed, as in the case of asbestos encapsulation, enclosure, or removal projects, asbestos fibers will become airborne. Once in the air, the asbestos fibers may be inhaled by workers performing these projects, posing a significant health risk. For these reasons, engineering controls and work practices such as wet methods are used to minimize the generation of airborne fibers. Since no method has been devised to remove asbestos without generating some airborne fibers, respirators must be used at all times. Further, protective clothing must be worn by all personnel. Lastly, other protective measures such as safety glasses, hard hats, or ear plugs may be required to protect the employee from other hazards.

There are three ways that hazardous materials can enter the body: (1) through the gastrointestinal tract, usually via the mouth (2) through the skin, and (3) through the respiratory systems. Asbestos does not appear to pose a serious threat to the body through the first or second routes of entry. It can, however, cause serious diseases when it enters the body through the respiratory system.

RESPIRATORY SYSTEM

The respiratory system is a gaseous (air) pump containing a series of airways leading from the nose and mouth down into the air sacs (alveoli) where there is an exchange of oxygen and carbon dioxide. The main components of the respiratory system, from top to bottom are as follows:

- Nose and mouth
- Throat
- Larynx (voice box)
- Trachea (wind pipe)
- Bronchi (branches from trachea)
- Alveoli (air sacs in the lung)
- Diaphragm and chest muscles

The human body has certain natural defenses to protect itself against inhaling dust, the most important being the muco-ciliary escalator. Airways of the upper respiratory tract (trachea through bronchi) are lined with cilia (hair-like protrusions) covered with a layer of mucous. These cilia are constantly sweeping upward quickly, then down slowly, and thus moving the mucous and trapped materials up at a rate of approximately one-inch per minute. This is an important clearance mechanism which prevents most large particles from reaching the alveoli in the lungs. Particles trapped in the mucous are carried back up to the throat where they are swallowed or expectorated. Unfortunately, this natural defense mechanism does not prevent all asbestos fibers from reaching the lung where damage can occur. Accordingly, respirators must be worn to provide further protection when asbestos exposure is likely.

9. ☐ Coordinate with the client the turning off of all air and exhaust systems to prevent building contamination.
10. ☐ Have the client designate a secure storage area for your equipment.
11. ☐ Prepare a damage list of the work area with client for any damages already incurred.
12. ☐ Inform the Foreman and Industrial Hygienist/Safety of the electrical panel box location, parking facilities, lunch room area, and lavatory facilities.
13. ☐ Plan the location of the MICRO-TRAP Units with the Industrial Hygienist to ensure maximum protection of area and personnel.
14. ☐ Hold a brief meeting each morning with the Foreman and Industrial Hygienist to discuss the day's activity.
15. ☐ Maintain the project blue print in the Command Area noting work progress to ensure scheduling.
16. ☐ Keep a log of important events on the job.
17. ☐ Make arrangements with the Industrial Hygienist to deliver each day's air samples to the laboratory.
18. ☐ Schedule and document the removal of waste material (such as, State and Federal manifests).
19. ☐ Assign a qualified person to take pictures if required.
20. ☐ Before an area is turned over to the client, be sure the area has been accepted and approved by the client in writing.
21. ☐ Before turnover, notify the client to reset thermostats, fans, electrical equipment, etc.

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SUPERVISOR RESPONSIBILITY CHECKLIST

Thoroughly familiarize yourself with job "Specifications".

1. ☐ Determine equipment needed on job, such as:
 - a. Vacuum cleaners
 - b. Micro-Traps
 - c. Wetting machines
 - d. Special riggings
 - e. Tools
 - f. Air sample pumps
2. ☐ Determine material needed on job
 - a. If required, order sufficient material such as:
 1. Coveralls
 2. Hoods
 3. Boot covers
 4. Gloves
 5. Respirators
 6. Replacement cartridges
 7. Polyethylene (4 and 6 mil)
 8. Duct tape
 9. Polyethylene bags (6 mil)
 10. Surfactant
 11. Spare filters and pre-filters
 - b. Keep accurate records on the use of material and reorder when supplies are low. Allow enough time to prevent a delay on the job.
3. ☐ All equipment must be checked and documented prior to delivery to the job site.
4. ☐ Check if the client has complied with the Client Checklist.
5. ☐ Coordinate with the client about electrical requirements for the job, and check the location of the panel box.
6. ☐ Check with the client to designate parking facilities for trucks, trailers, and cars.
7. ☐ Check with the client to designate an area for "break" and "lunch", with ample room for the number of men assigned to the job.
8. ☐ Have the client designate lavatory facilities

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(continued on next page)

TECHNIQUES FOR PROPER SUPERVISION

Supervisory practices to enforce and reinforce the required work practices and discourage unsafe work practices will include the following key elements:

- * Communication
- * Ensure adequate materials and equipment
- * Lead work
- * Recognize/correct hazards
- * Ensure crew follows proper work procedures
- * Documentation
- * Be on-site

Communication plays a major role in proper supervision of an abatement project. A good supervisor will demonstrate adequate communication skills not only with his crew but also with the building representative and other contractors on-site.

To ensure the abatement job runs smoothly it is the job of the supervisor to provide adequate materials and equipment are always maintained on the job site. The supervisor ensures the project starting off on the right foot by ordering sufficient amounts of materials and equipment to be delivered to the project site on or before the start up date. The continual success of a trouble free job relies on the appropriate amount of back up supplies be ordered in a timely manner by the supervisor.

A supervisor also needs to lead his/her workers by showing them the appropriate work practices required for that particular project. During the extent of the project the supervisor will also need to recognize and correct any hazards that could arise.

Documentation will also play a big role in the supervisor's responsibilities. Due to the fact of the liability associated with asbestos abatement projects a key job of the supervisor is proper documentation. A checklist is recommended to make sure all the vital information is recorded.

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The term synergistic effect describes the relationship between cigarette smoking and asbestos exposure. In simple terms, it means that smoking is unhealthy enough for a person, but when combined with asbestos exposure, the risk becomes multiplicative, and may in fact, significantly increase the chances of developing an asbestos-related disease. The smoking acts as a trigger in the development of health related problems.

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commercial buildings contain friable ACM than do school buildings (20% vs 35%). However, limitations in the data prevent firm conclusions regarding the number of persons exposed, exposure levels, or the exposure levels of service/maintenance workers in comparison with the public.

A mathematical model was developed by EPA to assess risk. Risk calculations suggest that if asbestos exposure is eliminated in schools, we have the potential to significantly reduce the overall risk for this segment of our population which may later be exposed to asbestos in public and commercial buildings. It should be noted, however, that though the elimination of exposure in schools may reduce risk, there remains a risk as the result of exposure to asbestos elsewhere.

Asbestos fibers accumulate in the lungs. As exposure increases, the risk of disease likewise increases. Measures to minimize exposure and consequently minimize the accumulation of fibers, reduces the risk of adverse health effects.

Despite the uncertainties associated with the risk of low level exposure, if we accept the fact that there is no safe level of exposure to asbestos we have cause to institute measures to control or eliminate exposure; regulations such as AHERA move in this direction.

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times more likely to contract lung cancer than the normal non-smoking population. Like asbestos, there exists a long lag time between initial exposure and the occurrence of lung cancer, typically 30 years. There appears to be a dose-response relationship between asbestos exposure and lung cancer, although no "safe level" has yet been determined. It should be noted, however, that several research papers published in the mid-1980s suggest there may exist an exposure level for certain forms of asbestos, below which, the occurrence of lung cancer related to asbestos exposure will not exceed that of the general population.

MESOTHELIOMA

The asbestos-associated disease of greatest concern regarding asbestos in buildings is probably mesothelioma. Fortunately, it is also the rarest. Mesothelioma is a cancer of the chest cavity lining (mesothelium). Mesothelioma can also occur in the lining of the abdominal cavity. If it occurs in the chest cavity, it is called pleural mesothelioma; in the abdominal cavity, it is known as peritoneal mesothelioma. This type of cancer spreads very rapidly and is always fatal. The exact mechanism of this disease remains unknown. There does not appear to be any increased risk of getting mesothelioma for smokers and there does not appear to be a dose-response relationship between asbestos exposure and mesothelioma. Cases have been recorded where the person's asbestos exposure has been limited, such as Steve McQueen, the actor. Like the other diseases of asbestos, mesothelioma often takes 30-40 years after initial exposure, if it occurs.

OTHER DISEASES

Several other diseases are found more often among persons exposed to asbestos than the normal population. These include cancer of the esophagus, stomach, colon, and pancreas, pleural plaques, pleural thickening, and pleural effusion. Again, the importance of using the proper work practices and respiratory protection cannot be overemphasized to minimize the occurrence of these diseases due to unnecessary asbestos exposure.

RISKS ASSOCIATED WITH LOW LEVEL EXPOSURE

Asbestos is known to be hazardous based on studies of asbestos workers and laboratory animals. However, the risks associated with low level, non-occupational exposure (for example, as an occupant of a building containing ACM) are not well established. Attempts have been made to estimate low level risks by extrapolation from occupational exposure data. This is not a straightforward process and its validity is questionable.

Based on a thorough review of the health effects literature, EPA concludes -- there is no level of exposure below which the risks of contracting an asbestos related disease are not zero. That is, there is no threshold level of exposure.

A 1988 survey sponsored by EPA attempted to assess exposure to ACM in public and commercial buildings. According to the data, a lower percentage of public and

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POTENTIAL HEALTH EFFECTS ASSOCIATED WITH ASBESTOS EXPOSURE

The adverse health effects associated with asbestos exposure have been extensively studied for many years. Results of these studies and epidemiologic investigations have demonstrated that inhalation of asbestos fibers may lead to increased risk of developing one or more diseases. Exactly why some people develop these diseases and others do not remains a mystery. In this discussion, each of the major diseases associated with asbestos will be examined, along with the risk and how that risk can be minimized.

It is important to recognize that the majority of people who have died as a result of asbestos exposure were asbestos workers. These workers were frequently exposed to high concentrations of asbestos fibers each working day with little or no protection. The asbestos abatement worker of today follows specific work practices and wears appropriate protection, including respirators, to minimize the risk of exposure.

THE RESPIRATORY SYSTEM

Since the primary health effects due to asbestos exposure act on the lung, it is necessary to gain a brief understanding of the respiratory system. Air which is breathed into the body passes through the mouth and nose into the windpipe or trachea. The trachea splits into two smaller airways called the bronchi. Each bronchus divides into smaller and smaller tubes which terminate into air sacs called alveoli. It is in these air sacs that oxygen is absorbed into small blood vessels and waste gases, such as carbon dioxide, pass out of the blood. (See Figure III-1)

The lung itself is divided into two halves and sits in the pleural cavity. This cavity and the outside of the lung itself have a membrane lining (called pleura) which looks somewhat like Saran-wrap. These linings are in contact with each other and are very moist. Just like two panes of glass with a drop of water between them, these linings slide easily across each other, but are difficult to pull apart. Accordingly, as the chest cavity expands, the lungs expand and air rushes in. If these linings were to become damaged, inhalation could not occur properly.

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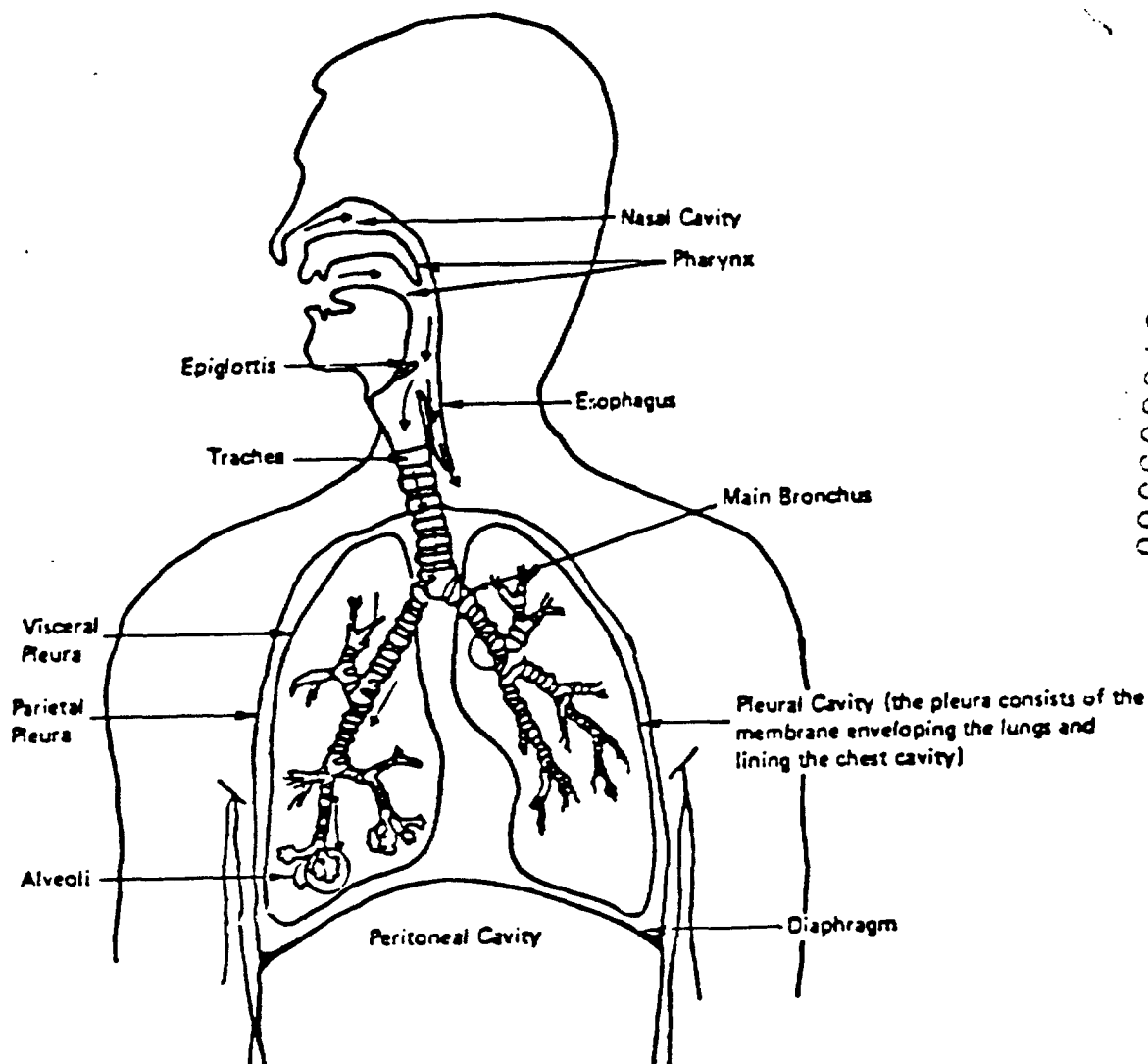


Figure III-1

Routes of inhalation and ingestion of asbestiform fibers are shown by small arrows. Mesothelial cells line the outside of the lungs and the pleural and peritoneal cavities. Interaction of asbestos with these cells can result in either pleural or peritoneal mesothelioma. Adapted from Wagner, 1980.*

*Figure from Asbestiform Fibers, Nonoccupational Health Risks, National Research Council, National Academy Press, Washington, DC (1984), p. 101.

The body has several mechanisms by which it "filters" the air it breathes. First, very large particles are removed in the nose and mouth. Many smaller particles impact on the mucous-coated walls of the airways and are caught. These airways have a hair-like lining (ciliated cells) which constantly beat upward. Accordingly, particles caught in the mucous are swept up into the back of the mouth. From here it is swallowed or expelled. Unfortunately, cigarette smoking temporarily paralyzes these ciliated cells inhibiting one of the body's natural defenses against unwanted dust. During the night, in absence of smoke, the hairlike cells start working again and carry large amounts of mucous into the back of the mouth. This causes the so-called "smoker's hack" in the morning. After the first cigarette or two, the cleansing mechanism is paralyzed again and the coughing stops. It should now be evident why cigarette smokers who are exposed to asbestos appear to be at greater risk. Other reasons will also be discussed later in this section.

Even with the above-mentioned natural defenses of the body, some dust particles inevitably reach the tiny air sacs. When this occurs, large cells (called macrophages) attempt to engulf the particle and "digest" it. For this reason, they are sometimes called the lung's garbage collectors. However, because asbestos is a mineral fiber, the macrophages are often not successful. When this occurs, these cells deposit a coating on the fiber and may begin forming scar tissue around it. This is just another natural defense mechanism the body uses against unwanted dust and debris in the lung. If many asbestos fibers are inhaled and much scar tissue is formed, a condition develops known as asbestosis.

ASBESTOSIS

Asbestosis is a disease characterized by fibrotic scarring of the lung. This is a restrictive lung disease which reduces the capacity of the lung. The common symptom is shortness of breath. Asbestosis is prevalent among workers who have been exposed to large doses of asbestos fibers over a long period of time. Accordingly, there is a clear dose-response relationship between asbestos exposure and developing this disease. This means the greater the asbestos exposure, the more likely asbestosis will develop. All forms of asbestos have demonstrated the ability to cause asbestosis. Like all diseases associated with asbestos exposure, it may take many years for the disease to show up. The typical latency period for asbestosis is 15-30 years.

Even after exposure to asbestos has ceased, scar tissue will continue to form around existing scar tissue and fibers in the lung. Limiting exposure will reduce the amount of new scar tissue since additional fibers entering the lung will be reduced. The current Occupational Safety and Health Administration (OSHA) Asbestos Standards (29 CFR 1910.1001 and 29 CFR 1926.58) were promulgated to greatly reduce asbestosis among asbestos workers by reducing their daily dose of asbestos.

LUNG CANCER

There are many causes of lung cancer, of which asbestos is only one. While employees exposed to industrial concentrations of asbestos in years past have an increased risk of getting lung cancer (5X), their risk is not as great as the cigarette smoker (10X). However, together, a cigarette smoker who also works with asbestos is more than 50

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