Lead Abatement On Bridges And Steel Structures

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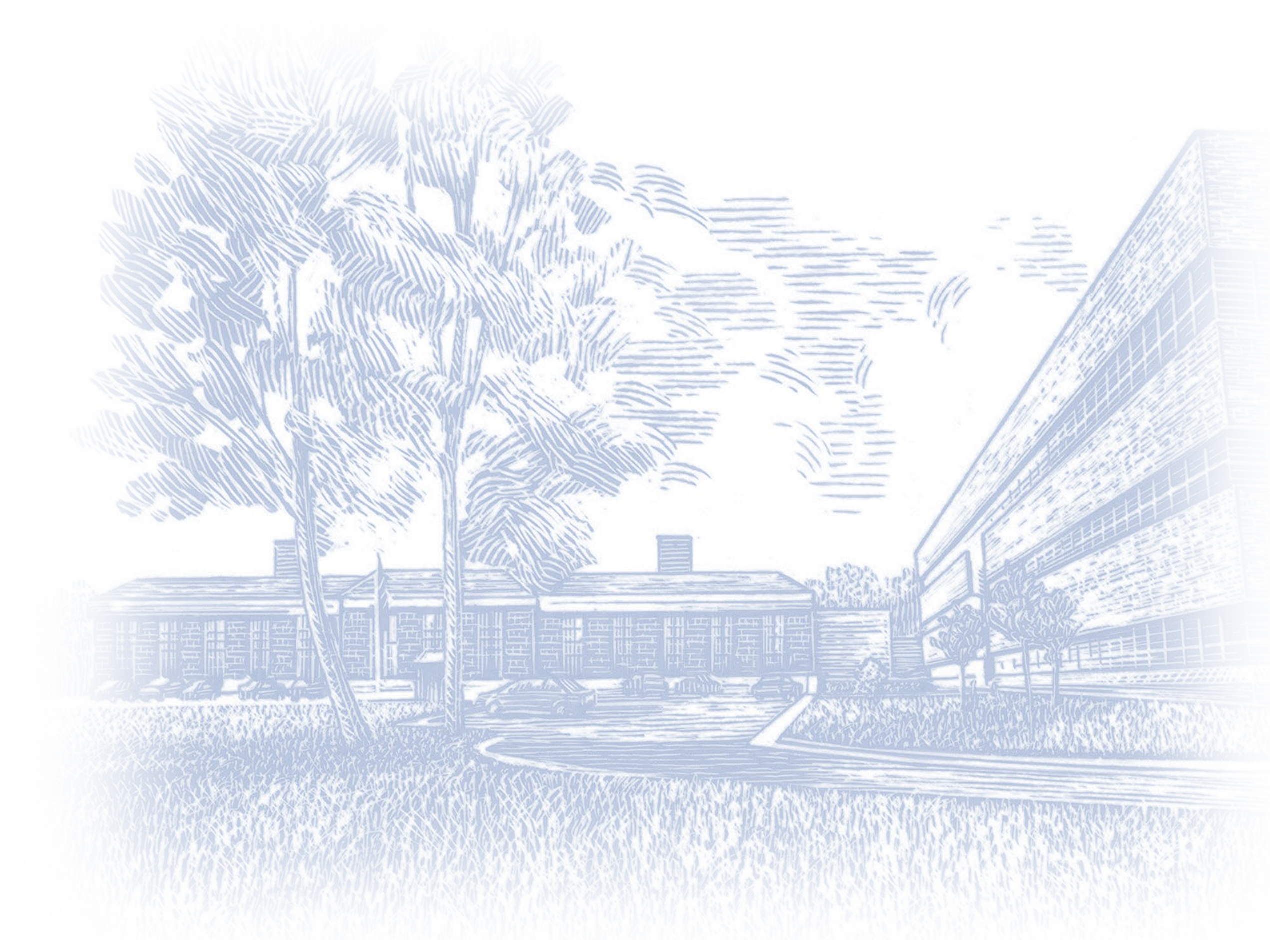

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Foreword

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   - Environmental lead exposure

   - Occupational lead exposure

2. List four examples of environmental exposure to lead.
3. List four examples of occupational exposure to lead.
4. Know the melting point and boiling point of lead.
5. Explain why lead is used as a coating on steel structures.
6. List the types of steel structures that commonly use lead-based coatings.

INTRODUCTION

Before there was alar, dioxin, or radon to terrify people that an unseen menace was poisoning them, there was LEAD.

A malleable, durable metal, as old as civilization, as old as the lead-lined aqueducts that brought water to ancient Rome, as old as a medieval lead goblet hoisted to a friend's good health, lead has from the beginning had twin reputations as a valuable resource and deadly poison. Even in Hippocrates' time, Greek shipbuilders knew that long days of pouring lead into molds for keels would leave workers retching and delirious. Overtime meant death.

In the late 1700s, Ben Franklin described various environmental and occupational effects which he attributed to lead, affecting trades, such as printers, plumbers, and painters. These descriptions are found in a letter that Franklin wrote to a friend.

In the early 1900s, detailed information on the hazards began to appear. First, a study in Britain linked exposures to lead with high rates of infertility, stillbirths, and first year infant deaths. About the same time, an Australian study observed lead poisoning among children and identified household dust and paint as the sources of the lead. Childhood activities, such as nail-biting, thumb-sucking, and eating with fingers contaminated with lead are the ways lead was introduced into the body.

In this way, lead differs from many of the more recently minted environmental toxins; no need to wonder whether a substance that seems subtly dangerous in test tube experiments or animal studies might also pose a threat to humans. The evidence has been blatant for centuries. Eat a little lead often enough and you get sick; eat a little more and you can die.

But the idea that the metal might damage the mind long after other physical symptoms have abated, or even before they develop, has been slower to catch on. It was Herbert Needleman's mentor, a courtly Boston doctor named Randolph Byers, who provided some of the first clues.

As a Harvard professor and pediatrician at the Children's Hospital lead clinic in 1939, Byers treated inner city toddlers who had cut their teeth on the rails of lead-painted cribs or on window sills. Over the course of weeks or months, they developed the pallor, vomiting, and listlessness linked to overt lead poisoning. In those days doctors believed that if they could prevent the brain from swelling, there was no risk of long-term damage. After a few weeks of extra milk and cod liver oil, children treated for poisoning were sent home from the hospital "good as new."

On the hunch that damage from lead ran deeper than anyone imagined, Byers and Harvard psychologist Elizabeth Lord kept tabs on the children's mental development for several years. What they discovered worried them: By 1943, all but two of the 20 children in the study were having serious academic problems; several had not learned to read or write even by age eight or nine.

Tests also showed the sort of outbursts characteristic of people who suffered damage to the brain's cerebral cortex, Byers and Lord reported: "Three were excluded from school on the basis of behavior, one for setting fires in the school, another for repeatedly getting up and dancing on desks and other furniture and the third for sticking a fork into another child's face." Roman peasants often called their leaders mad when the rich used lead as a sweetener for food and drink.

To Lord and Byers, the most frightening aspect of their study was that this profound damage had such a quiet beginning. It seemed likely that many more toddlers than anyone imagined were having their intellects and, perhaps, personalities silently mangled right under well-meaning parents' noses.

The findings made an immediate splash in the press and public circles. A 1943 Times magazine article entitled "Paint Eaters" detailed the Byers-Lord study and warned: "If your child is slow with building blocks, but quick on tantrums, he may be a lead eater.... And not many Doctors realized that one consequence of the plumbic passion in children may be stupidity."

Previously we have discussed the use of lead in ancient times and the health effects that lead may have caused. Now lets speak about the use of lead in today's world.

MODERN DAY USES OF LEAD

Lead has been used since ancient times as a paint pigment. Two major chemical forms of lead are used as colors--they are called "white lead" (a lead carbonate) and "red lead" (a lead oxide). Both types of lead provide a thick, heavy, tough coating, one that does not crack through wear or temperature variations, because it can expand and contract in unison with the base metal to which it is attached. In addition, the chemical nature of lead causes it to provide corrosion resistance as well. Because of these properties, lead paints have been and continue to be widely used for bridges and other metal structures.

The overall amount of lead that has been used can be considerable--one estimate for the Sydney Harbor Bridge in Australia is that 90 tons of red lead paint and 250 tons of battleship gray are used in a five-year painting cycle. The bridge itself contains 51,300 tons of steel. Some old structures may have a thick coating from decades of painting. Even new steel is often coated with lead paint. This may be surprising to some, because many people are under the impression that lead paint has been banned. It is true that lead has been prohibited for use as a residential interior finish. But it continues to be used for many exterior uses. Even if lead were banned today for new use on structural steel, construction workers would still face a lead hazard for the next 25-50 years, because there are so many old structures that contain it. It is estimated that 35%-40% of steel structures are coated with lead-based paint, including 90,000 bridges. Of all bridges repainted in 1985-1989, 80% of them had lead coatings. Because demolition and repair are likely to be increasingly important in the future as the Nation faces its "infrastructure problems," it is important that every construction worker be aware of this hazard.

For some Laborers, the idea that the job can involve lead exposures may be a new one. After all, lead is not a common item on the work site. It is not often present in structural steel alloys, nor used as a specialty product. It may be present as a thin film of paint, but this may seem like an unlikely possibility for causing a problem. Well, if you ask anyone who has done any renovation or demolition work on old steel structures lately, you begin to understand the problem. It is typical to use oxyacetylene torches to cut on old steel structures or to use welding equipment to weld on them. The high temperatures of the torch or welding process vaporizes the lead, so it becomes airborne and available for the worker to breathe. The purpose of this course is to explain the nature of the hazard, provide recommended work practices to allow safe work, and to describe the relevant regulations and guidelines for lead. Because lead is such an important hazard, it is covered by a very tough OSHA standard. The Lead Standard will be reviewed in this course because it addresses many of the hazards involved with lead exposure.

Environmental Exposures to Lead

Environmental lead exposures are those that occur outside the workplace. Airborne lead, resulting from either auto emissions or industrial sources, represents an important source of this exposure. Direct breathing of lead dust in the air can contribute to lead intoxication, as can the intake of soil or dust which has been contaminated by lead. The elimination of leaded gasoline has contributed to the overall reduction of the environment lead levels. This effort has reduced levels of lead in the blood of the general population more than any other single factor.

Lead-contaminated drinking water also contributes to the level of exposure. In most cases, lead in water has been leached from lead tanks and pipes, or from lead soldered copper pipes by soft water with an acidic pH. pH is a measure of the acidic or basic nature of a liquid. Normally, water has a pH that is neutral or 7. By comparison, vinegar (acidic) has a pH of about 3 and drain cleaners (basic) have a pH of about 12.

Recreational use of lead can also be linked to similar problems found on steel structures. Both fishermen and waterfowl hunters that produce their own lead weights by heating bar lead to its molten state produce the same fumes which are given off by heating lead paint on bridges. Many outdoorsmen who produce their own lead weights, which they acquire from gas stations, also must contend with the problem of the petroleum byproducts found on the surface of the lead which are also heated and produce toxic fumes. Skin divers may also pour their own weight belts. Manufacturers are still producing lead shotgun shells for use on upland game. The problem here is not so much to the human but to the environment itself. Many game animals may only be wounded only to die later unfound by the hunter. Along comes a bird of prey, such as the eagle, and by eating the dead carcass the eagle can die of lead poisoning. This problem resulted in the use of steel shot for waterfowlers.

Lead is also used for stain glass window production. Here again the lead is made molten and then poured between the pieces of stained glass. This holds the glass in place and gives the window, lamp shade, or decoration a very distinct look. With this beauty also comes the health hazards associated with molten lead.

One other area in which lead may be found in the home is a crystal decanter. If alcohol is left in the decanter for any length of time the lead may leach into the alcoholic beverage causing the unsuspecting person to become ill.

Occupational Exposures to Lead

Occupational lead exposures are exposures that occur on the job. Adults working in lead-associated industries, such as smelting, auto body repair, battery manufacturing, and home remodeling, will have increased exposures to lead. In addition, they may expose their families by bringing lead-contaminated dust into their home with dirty work clothes, shoes, hair, and body.

It is the occupational exposures that are of concern to us in the removal or abatement of lead. There are many applications of lead and lead products that will create exposure as we do our jobs on construction, renovation and repair, or demolition.

In today's world anything which is made of iron/steel and comes in contact with the elements will develop a rust problem. Bridges, water towers, outdoor stadiums, and some electrical towers fall into this category. In order to have the iron/steel last it must have a protective coating placed upon it to preserve it. Paints with lead additives are the best way to protect the metals. Year after year the bridges of this country are coated over and over with lead paint.

Lead paint on bridges and structural steel and concrete creates hazards when cut with torches and saws. Lead melts at 621ºF and boils at 3164ºF, or well below the temperature at the tip of a cutting torch. The lead is vaporized when exposed to the high temperature of the torch and this vapor is then available to be breathed in. Dust is generated by cutting with cut-off saws, scraping or sanding, or sandblasting lead coated materials. This dust is also hazardous because it may be in the air (to be breathed in), or as larger dust particles. These particles settle on surfaces and hands, and can then be ingested when workers eat lunch or smoke.

Paint containing lead is used to protect the infrastructure from rusting out. Here the paint is applied to the steel member before being placed and acts as a protective barrier against air pollutants, acid rains, and anything else that may attack the metal and start its decay. Lead handles this job in a very effective way because of its elasticity, meaning it has the ability to move with the steel either in expansion or contraction.

During the construction of buildings, lead has been used in water and sewer pipes; joint materials for pipe; solder and electrical connections; linings of tanks, vessels, and vats; and roofing materials, such as cornices, gutters, and flashing. It is safe to say that when renovation or demolition occurs where lead-containing products are involved, there will be the potential for lead exposure.

Elsewhere in this manual you will learn of the effects on both the environment and on humans from lead-coated surfaces. Many laws are changing to protect the environment and the populations of this country. It is up to each and every one of you to make sure that the new laws are followed and you, your families, and the environment are protected.

ASSIGNMENT SHEET

1. Define the following terms:

   Environmental lead exposure ______________________________

   ____

   ____

   Occupational lead exposure ______________________________

   ____

   ____

2. List four examples of environmental exposure to lead.
   1) ____
   2) ____
   3) ____
   4) ____

3. List four examples of occupational exposure to lead.
   1) ____
   2) ____
   3) ____
   4) ____

4. What is the melting point and boiling point of lead?

   Melting Point ______________________________________

   Boiling Point ______________________________________

5. Why is lead used as a coating on steel structures?

   ____

   ____

6. List the types of steel structures that commonly use lead-based coatings.

   ____

   ____

HEALTH EFFECTS

TRAINEE OBJECTIVES

After completing Section 2, you will be able to:

1. Define the following terms:

   Acute health effects

   Chronic health effects

   Chelation

   Inhalation

   Ingestion

2. Identify the main routes of entry for lead entering into the body.
3. Understand where lead goes once in the body.
4. Know the short and long term symptoms associated with lead exposure.
5. Understand the organ systems that can be damaged by lead.
6. Understand the special hazards that lead poses for young children.
7. Know the types of medical tests used for detecting lead exposure.

INTRODUCTION

Lead has been shown to cause a wide variety of health effects. Many of the effects have been known since ancient times, although some of the more subtle effects have been discovered only recently. It is important to have a good understanding of the toxic effects of lead, so the hazards will be described in some detail.

HOW LEAD CAN ENTER THE BODY

It is important to understand the ways that lead can get into the body. This is referred to as routes of exposure. With lead, there are three possible routes of exposure.

- Inhalation
- Ingestion
- Absorption

Inhalation

This is by far the most important exposure route. Lead may be in the air if dust is created by grinding or similar procedures, or if fumes are created by welding torches. In most situations, high levels may be present yet not be visible to the naked eye. This airborne material is easily breathed in by any workers in the vicinity. Once inhaled, air follows a pathway from the nose to the windpipe (or trachea), which then forms two air passages (called bronchi), one to each lung (Figure 2-1).

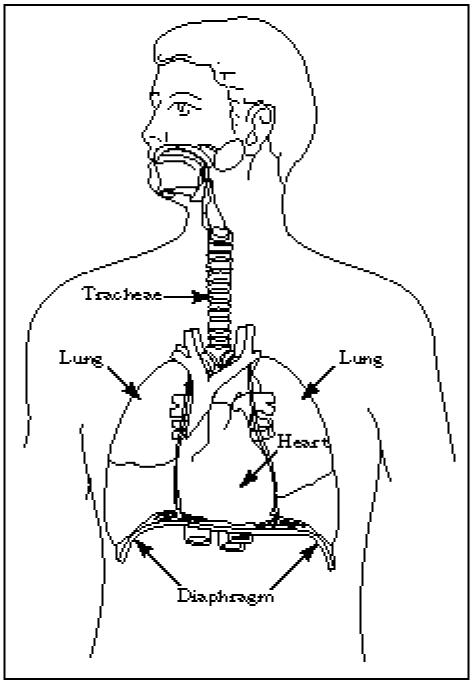


Figure 2-1. Air passage to the lungs.

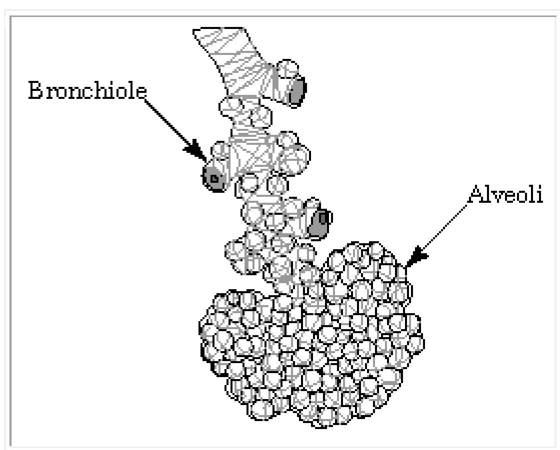


Figure 2-2. Bronichioli and aveoli.

The bronchi branch extensively and end in clusters of tiny air sacs called alveoli (Figure 2-2). There are millions of these tiny air sacs, so that the lung actually provides an enormous surface area. This surface area, combined with the delicate cells of the alveoli, allows oxygen to pass readily into the blood stream. Unfortunately, it also gives any contaminant an easy access as well. The body does have some defenses to protect the delicate lung tissues. These defenses include nose hairs to filter out large particles, and a mucous system in the bronchi to trap medium size particles. These defenses do not work very well for very small particles. This is why lead fumes, which are very small particles of lead, are so much more hazardous than lead dust as far as inhalation exposures are concerned.

Ingestion

This route of exposure is the one that has been of concern for small children. Interior paint chips are sometimes swallowed by children, a problem made worse by the fact that lead paints sometimes have a slightly sweet taste. Kids also like to mouth toys and objects. The digestive system will absorb much of the lead into the bloodstream, and the resulting exposure can cause severe lead poisoning. Because of this, lead paint for use on interior surfaces and toys has been banned for many years.

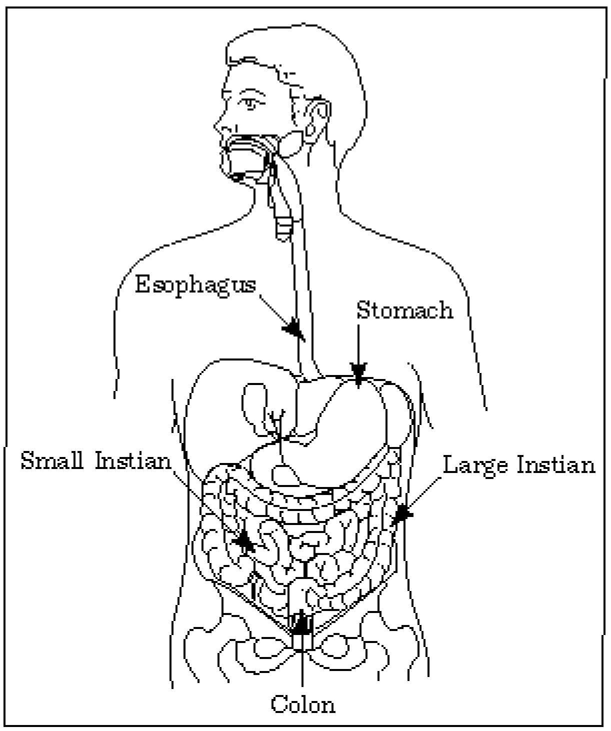


Figure 2-3. The digestive system.

Although adult workers are not exposed this way, ingestion exposures can happen on the job in surprising ways. There have been documented cases where workers consumed significant amounts of lead via contact of dusty unwashed hands with food and even cigarettes. Figure 2-3 illustrates the digestive system.

Ingestion exposure can also occur indirectly due to inhalation. Remember that inhaled medium-sized particles can get trapped in the mucous lining the major breathing passages. The mucous is eventually swallowed, and some of the lead is then absorbed by the digestive system. In the past, the practice of having lead-exposed workers drink milk was an effort to "coat" the stomach so as to minimize the absorption of lead. You can see that it would only be partially effective if at all, especially because it does not affect the primary exposure route-inhalation.

Absorption

Absorption is when a substance enters the body through the skin. Certain lead compounds will be absorbed through the skin. These are mainly organic lead compounds such as tetraethyl lead (commonly found in leaded gasoline). The lead compounds construction workers are exposed to are inorganic. Inorganic lead compounds are added to paint such as lead oxide or lead carbonate. Inorganic lead compounds are believed to not be readily absorbed through the skin although this route of exposure needs further study.

WHERE DOES LEAD GO IN THE BODY?

Once in the bloodstream, lead is circulated throughout the body and stored in various organs and body tissues. One such organ is the kidney. It is the job of the kidney to purify the blood before it is distributed for use by the rest of the body. However, the kidney is not effective in removing much of the lead. Furthermore, studies show that the lead can damage the kidney. Much of the lead is carried by the bloodstream to other organs of the body, where some of it is stored. Lead is also stored in long bones (such as the thigh, or forearm), in organs, such as the liver and kidney, and in fatty tissue (including the fat surrounding nerve cells). The lead stored in the long bones can be kept for a long time. The total amount of lead stored in the body is called the "body burden." Lead stored in the body is slowly released over time. This is a very significant aspect of the lead hazard for Laborers. It means that the body can continue to be exposed to lead months or years after the actual on-the-job exposure is finished!

THE EFFECTS OF LEAD EXPOSURE

Toxic effects are typically broken down into two categories:

- Acute (short-term) effects.
- Chronic (long-term) effects.

Some substances, such as asbestos, do not have short-term effects. Diseases from asbestos take many years to develop. Lead does have short-term effects, although there is not a sharp dividing line between the short-term effects and the longer term effects.

Acute Effects

These effects show up relatively soon after exposure occurs. Lead is a potent, systemic poison that serves no known useful function once in the body. Very low lead exposures do not cause any short-term effects. On the other hand, excessive exposures (very high doses) can lead to a variety of symptoms. These include:

- Metallic taste in the mouth
- Stomach pain and vomiting
- Diarrhea
- Black stools

Severe exposure can cause nervous system damage, with symptoms, such as intoxication, coma, respiratory arrest, and even death.

Chronic Effects

These types of effects take some time before they begin to develop. For example, the chronic cancer effects from asbestos take 20 years or more to show up. For lead, a wide variety of chronic effects can be set in motion by continued exposure. Keep in mind that the problem is made worse because the lead can accumulate in the body. The immediate symptoms often seen with significant long-term exposure include:

- Loss of appetite
- Constipation, nausea
- Stomach pain (called lead colic)
- Pallor (a yellowing of the skin)
- Excessive tiredness
- Weakness
- Weight loss
- Insomnia
- Headache
- Nervous irritability
- Fine tremors
- Numbness
- Dizziness
- Anxiety
- Hyperactivity.

Because these symptoms are common to a variety of health problems, they are often over looked by exposed workers. For some, these symptoms may disappear when exposures stop. For others, symptoms can progress to problems associated with classic lead poisoning. These problems are more noticeable and unusual. They include:

- Severe stomach pain
- Extreme weakness
- Tremors
- Gum discoloration (a blue line on the gums)
- Wrist drop, foot drop
- Convulsions
- Kidney failure.

Doctors call these "clinical signs" as they are readily observed by doctors during a physical exam. On the other hand, at low doses lead can cause health damage without any noticeable symptoms. To better understand chronic effects, lets take a look at the body systems affected by lead.

Effects on the Blood (Circulatory) System

Red blood cells serve to carry oxygen to the body's tissues. It is actually a blood protein called hemoglobin which does this work and which gives the blood its red color. Lead interferes with the body's ability to make hemoglobin. This disrupts the flow of oxygen to all tissues, causing anemia. Anemia, which is a general term describing an oxygen shortage, is linked with symptoms, such as tiredness, weakness, headache, and irritability. Severe anemia can lead to heart failure.

Effects on the Nervous System

While the exact mechanism is not understood, chronic lead exposure can cause important nervous system problems. It can affect the central nervous system which includes the brain. This may show up as fatigue, nervousness, anxiety, and sleeplessness, and lead to behavioral problems, such as poor memory, visual disturbances, and confusion. In very severe cases, encephalopathy (pronounced, en-sef-a lop-a-th', a degenerative brain disease) and serious psychological problems can occur. In addition to the brain, lead can affect the part of the nervous system that controls the movements of hands, fingers, and feet. It is called the peripheral nervous system. For example, severe lead poisoning can cause "wrist drop" or "foot drop" where the damaged peripheral nerves cause weakness and/or paralysis of the hands or legs. Doctors call this condition "peripheral neuropathy." Other more subtle problems, such as a decrease in hand-eye coordination, can also occur. These nervous system problems can sometimes clear up if they are mild, but they can also be irreversible in other cases.

Effects on the Kidneys (Renal System)

Lead is linked with serious kidney damage. There have been cases where lead-exposed workers lost 30-50% of their kidney function. One of the problems with kidney damage is that few symptoms show up. Lab tests typically reveal this type of kidney disease only after two thirds of kidney function is gone. While the kidneys have "excess capacity," it is also true that by the time serious damage is noticed, it is sometimes too late to correct or prevent worsening conditions. Kidney dialysis or death can be the end result. Some studies also link toxic effects on the kidneys with hypertension and blood pressure problems. There is some evidence from animal studies that lead can cause kidney cancer as well.

Effects on the Reproductive System

Lead is linked with reproductive effects in both men and women. In women, lead exposure is associated with:

- Abnormal reproductive cycles
- Menstrual disorders
- Sterility
- Spontaneous miscarriages
- Stillbirths, and premature births.

Infants of mothers with lead poisoning have suffered from slower growth and nervous system problems. Also, death was more likely in the first year of life.

For men, lead affects are equally as severe, and include:

- Decreased sexual drive
- Impotence
- Inability to produce healthy sperm.

This symptoms can lead to a failure to conceive. Furthermore, genetic damage to sperm can result in miscarriages, stillbirths, or birth defects.

Effects of Lead Exposure on Children

It is very easy to bring home small amounts of lead from the job on clothes. This may seem like a trivial amount, but you need to know that children are especially vulnerable to the effects of lead exposure. This is because their nervous system is still developing and lead damage at this early stage can cause serious health consequences. As researchers study the situation more, they find that important health effects are caused by even very low exposure levels-levels once thought to be safe. Studies show that even small amounts of lead delay mental development, lower IQ scores, impair hearing, and even affect balance. This nervous system damage may be irreversible. Other effects include toxic effects on the kidney, impaired Vitamin D balance, and red blood cell problems. Figure 2-4 compares the health effects of different blood lead levels of adults and children.

THE ROLE OF MEDICAL TESTING IN CONTROLLING LEAD HAZARDS

Lead is unique compared to many other toxins in that there are short-term blood tests that can detect its presence.

While the tests have limitations, together they can help doctors to learn about a person's "body burden" of lead. The tests are described below.

Blood Lead Level Test (BLL)

This test gives a picture of the amount of lead circulating in the blood (or blood lead level). Results are given in either micrograms of lead per deciliter (µg/dl) of whole blood, or micrograms of lead per 100 milliliters (ml) of whole blood (µg/100 ml). Because lead is so common in the environment, the average urban dweller has a blood lead level from 12-15 µg/dl. The average level is going down over time as leaded gas usage declines. Lead can cause health damage at around 40 µg/dl, although many workers will not experience symptoms at this level. At 40 µg/dl children experience symptoms much greater than adults due to their size. At levels of 60 µg/dl and up, symptoms begin to develop in most workers. Levels above 80 µg/dl are likely to cause serious lead poisoning. The OSHA Permissible Exposure Limit (PEL) was established to keep blood lead levels below 40 µg/dl.

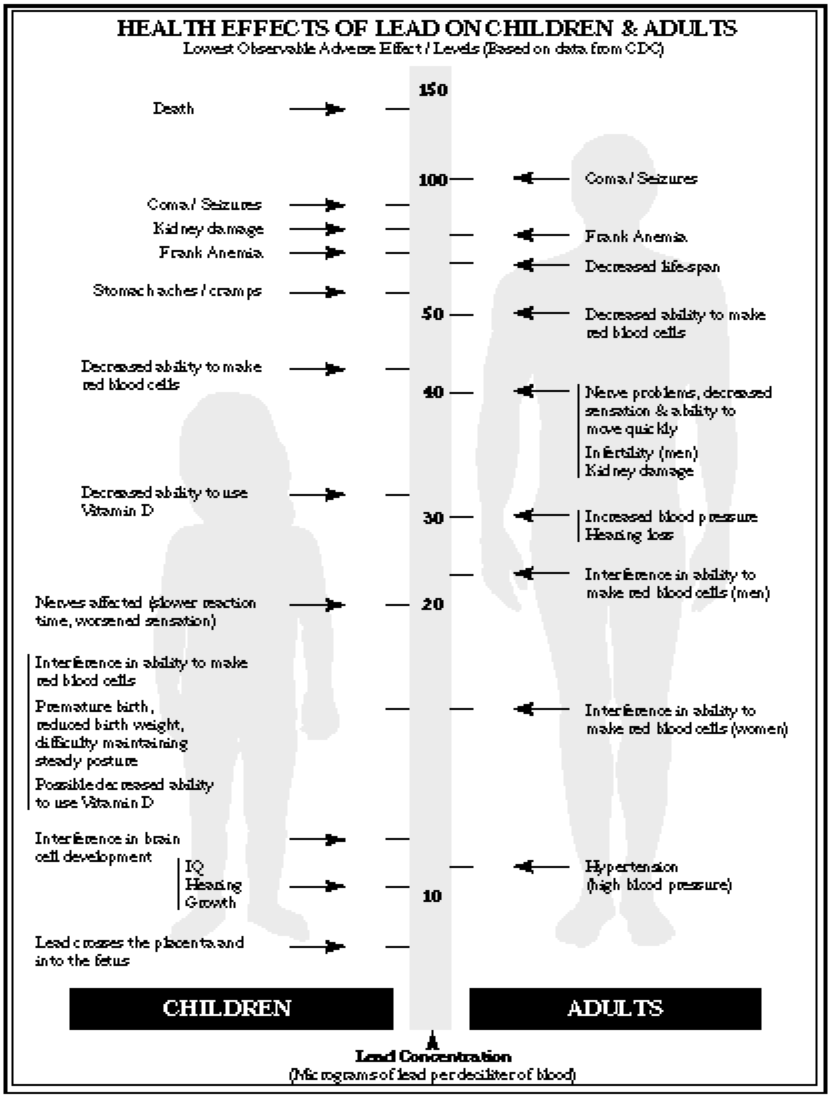


Figure 2-4. Health effects of lead for children and adults.

The blood lead level test is very valuable. It requires a tube of blood taken from the arm. It provides proof that exposure has occurred, and it gives an estimate as to how serious the exposure has been. To appreciate the availability of such a test, you have to compare the situation with asbestos, where there is no short-term test of any kind to indicate that a person has been exposed.

The test must be interpreted carefully. It tends to reflect recent exposure (within a week) to lead. It does not measure body burden directly, nor does it measure health damage. Simply stated the blood lead level test identifies the amount of lead in your blood at the present time.

Zinc Protoporphyrin Test (ZPP)

The zinc protoporphyrin (ZPP) test is used in conjunction with the BLL test. The ZPP test measures how much the blood-forming process has been interfered with by lead. Unlike the BLL test, the ZPP test does measure the actual harmful effect lead has had on the body. It is easy to perform, as it requires only a drop of blood from a pinprick. The analysis is done by a machine. It reflects the lead exposure over the preceding 3 to 4 month period.

These are the two most common tests. They are required to be provided to lead-exposed workers along with physical exams and other lab tests. In fact, the OSHA Lead Standard for construction requires that employees who are regularly exposed to lead be provided medical tests by the employer. OSHA uses a cut off of 30 days a year at about one-half the exposure limit to trigger this requirement.

The medical surveillance portions of the OSHA Lead Standard are very extensive. They address issues, such as:

- The frequency of regular testing.
- The frequency of testing when elevated blood lead levels are found.
- The notification of results due the employee.
- The content of the testing.
- The rights of employees to receive fertility or pregnancy testing if planning a family.
- The rights of employees to have a second physician review the initial physicians findings.
- The practice of using a third physician to resolve any differences of opinion between the first two physicians.
- The information that the employer must provide the examining physician.
- The form of the physician's written opinion.
- The prohibition against the physician communicating any information to the employer about non-lead questions (i.e., drug or other health problems).
- The conditions under which an elevated blood lead requires that an employee be temporarily removed from lead exposure.
- The conditions for returning such an employee to lead exposure.
- The maintenance of earnings of employees who must be removed from exposure.

It is important to properly understand the role of medical testing in an overall approach to protecting workers from lead. Prevention of exposure is the first line of defense. It serves as an important quality control check to tell you if the preventive measures are working. It can help alert workers and doctors to potential problems even when symptoms are general or unclear. It can allow intervention and treatment to reduce the chances of lasting damage. As part of an overall program, it allows true confidence that work around lead can be done safely.

MEDICAL TREATMENT OF LEAD POISONING

Medical treatment of workers with lead poisoning involves removal from further exposure and sometimes involves administration of special drugs called chelating agents.

Chelate is a Latin word for claw and these drugs work by latching on to lead in the body. The most widely used chelating agents are:

- Calcium Disodium EDTA (Ca Na2 EDTA)
- Calcium Disodium Versenate (Versenate)
- d-Penicillamine (penicillamine or Cupramine)

Once administered (orally or by injection), the chelating agent binds to the lead and is then excreted from the body (through urination) carrying the lead along with it. The problem is that chelating agents also latch on to other mineral nutrients, such as copper, calcium, manganese, iron, and zinc, causing the body to become run down.

Because of this potential problem, chelating agents must only be given under the strict supervision of a doctor. Years ago, some employers would use a procedure know as "prophylactic chelation" where heavily exposed workers would be routinely given these drugs instead of reducing the exposures. This is not an accepted medical practice and it is forbidden by the OSHA standard.

Chelation is an important tool for ridding the body of excess lead. It does not protect or cure lead-inflicted damage to tissues. It does limit the lead available to cause such damage. Exposed workers should consult with an occupational physician about the suitability of such treatment. Keep in mind that chelation is a last resort. Chelation can be a very painful process.

HEALTH EFFECTS STUDIES ON THE IRONWORKER TRADE

You can see that lead hazards have been studied quite a bit. You should also know that several studies have actually been done on construction trades performing work on steel structures.

These studies show that lead poisoning is a serious problem for this trade. A few studies are described below.

Case Study #1

Local union members in New York City participated in a 1974 study with the Mt. Sinai School of Medicine. The job involved 34 members dismantling a seven-mile section of elevated subway. Medical exams for these workers found 28 had blood lead levels over 40 µg/dl. Three had levels over 100 µg/dl and another 9 had levels over 80 µg/dl. Short term health complaints included stomach cramps and constipation.

Case Study #2

A 1984 follow-up study by Mt. Sinai found continuing problems among union workers. Testing of 97 members working on 6 different jobs involving torch demolition found that 55% of burners had elevated blood lead levels and ZPP values. Thirty percent had blood lead levels over 60 µg/dl and 9% had blood leads over 80 µg/dl. The highest value found was a very dangerous 128 µg/dl. The study found that burner assistants were also affected, with 29% having elevated levels. This shows that workers in the immediate vicinity of the burners are also at risk.

Case Study #3

A 1988 report from California described a case where a worker got lead poisoning after just three days of torch work. The worker experienced cough, chest pain, nausea, vomiting, stomach cramps, and constipation. Although he left the job, he developed headaches, instability, poor concentration, insomnia, depression, and weakness in the right wrist. A blood lead test after a week gave a value of 92 µg/dl. Follow-up testing seven months later still found nervous system effects, such as depression, impairment of attention and concentration, and memory problems. He also had wrist drop, headache, insomnia, and decreased sex drive.

In summary, the availability of lead-specific medical tests has allowed studies to be done in a number of settings. These studies provide strong evidence of a serious hazard. More follow-up studies are needed to determine the long term health effects on Laborers. You can see that lead is linked to a large variety of health problems. While the effects are obvious for some, other symptoms and problems are seemingly general in nature, and are not likely to raise a red flag with most members. Training on the health effects is important.

1. Define the following terms:

   Acute health effects

   ____

   ____

   Chronic health effects

   ____

   ____

   Chelation

   ____

   ____

   Inhalation

   ____

   ____

   Ingestion

   ____

   ____

2. List the two main routs of exposure for lead entering the body.

   ____

   ____

3. Where does lead go once it enters the body?

   ____

   ____

4. What are the short and long term symptoms associated with lead exposure?

5. What body systems and organs are damaged by lead?

6. Why is lead exposure such a potential hazard to young children?

7. What are two biological tests used for detecting lead exposure?

OSHA LEAD REGULATIONS

TRAINEE OBJECTIVES

After completing Section 3, you will be able to:

1. Write out the following acronyms:

   EPA
   OSHA
   PEL
   AL
   MRP
   CPSC

2. Identify the four items an employer must do if you are exposed to lead and are covered under the OSHA Interim Lead Standard for Construction (29 CFR 1926.62).

3. Define Medical Removal Protection and describe how it works.

4. List the three Presumed Exposure Task Categories, provide examples for each task, and list the corresponding exposure range.

5. List the Action Level and Permissible Exposure Limit for lead under the OSHA Interim Lead Standard for Construction (29 CFR 1926.62).

6. Describe what practices are prohibited in a lead regulated area.

7. Define how often an employer must provide blood lead level tests to affected employees.

INTRODUCTION

The Occupational Safety and Health Administration (OSHA) Interim Lead Standard for Construction will be presented and reviewed in this section. The complete standard is provided as an Appendix to this training manual. That standard is referred to as 29 CFR 1926.62. The term CFR stands for Code of Federal Regulations. The standard is called an Interim Standard because the Congress directed OSHA to issue the Interim Standard within 180 days of the signing of new federal legislation in 1992 known as TITLE X. OSHA is working on the Final Lead Standard for Construction, but it will not be issued as a final rule for a number of years.

OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION (OSHA)

OSHA is responsible for establishing and enforcing work place safety and health standards. Under specified conditions, Federal OSHA can approve occupational safety and health programs to achieve the same objectives by individual states. These are called approved State-Plan-States. Currently, 23 states have approved State OSHA programs. In those states, the OSHA inspector will be a State OSHA inspector, not a Federal OSHA inspector. One condition of becoming an approved state OSHA is that the state must make the regulations applicable to government employees in the state at the local and state government level. Two states, New York and Connecticut, have approved programs that apply ONLY to state and local government employees within the state.

In the other 25 states under Federal OSHA jurisdiction, the OSHA regulations do not apply to local and State government employees. Therefore, construction work involving the employees of local or state government may not be covered by the OSHA regulations as they are "government" employees. However, if you are working in these places for a contractor doing construction work involving lead, that contractor IS covered by the OSHA regulations whether federal or state, and you must be provided the protections afforded by the OSHA Interim Lead Standard for Construction.

In Washington, D.C. on October 29, 1992, President Bush signed into law Title X of the Housing and Community Development Act of 1992 (the Residential Lead-Based Paint Hazard Reduction Act of 1992). Under Title X, Congress directed OSHA to issue an interim lead standard for construction within six months of the signing of Title X. This Interim Lead Standard for Construction is designed to protect construction workers from the hazards of lead while OSHA continues to develop a final construction lead standard.

The key provisions of Title X are:

- NIOSH has been put in charge of a training grant program for the training and education of workers and supervisors, with $10 million authorized for this purpose each year from 1994 to 1997.
- The Environmental Protection Agency (EPA) is required, within 18 months (April 1994), to issue regulations that those engaged in lead-based paint activities be trained, that training programs be accredited, and that contractors engaged in this work be certified. States may be authorized by EPA to carry out this program within their jurisdictions.
- The Housing and Urban Development (HUD) Department is required to conduct a comprehensive study of methods to reduce hazardous occupational lead abatement exposures.

The OSHA standard became effective on June 3, 1993. All provisions must have been in place, with the exception of engineering controls, within 60 days after that date. The engineering controls must be in place within 120 days of June 3, 1993 (the first week of October, 1993). As of today, all provisions of the OSHA Interim Lead Standard are in place although we are still awaiting the Final Standard at this time.

Key provisions of the new OSHA Interim Lead Standard for Construction are reviewed in the following subsections. It is important to note that the Interim Standard applies to all construction activities where workers may be exposed to lead. This includes lead-based paint abatement in private, public, and commercial-use buildings; bridge work; steel superstructures; and demolition where lead-based paint is present. The standard also covers work in construction involving other materials containing lead which are not lead-based paint. This includes lead mortar, lead burning, and hazardous waste site work with lead contaminated soils, for example. Do not let anyone tell you that the Interim Standard applies only to lead-based paint work.

SCOPE OF THE STANDARD

All construction work involving exposure or potential exposure to lead is covered by the Interim Standard. This includes lead paint abatement, work on bridges and steel structures that are coated with lead-containing materials, demolition of structures where lead or materials containing lead are present, and removing or encapsulating materials containing lead. If you are doing any work in construction which involves lead, your employer is required to comply with the standard.

EXPOSURE LIMITS

The standard establishes two exposure limits: the PEL (Permissible Exposure Limit) and the AL (action level). The PEL is a Time Weighted Average (TWA) exposure limit averaged over an 8 hour work shift. The PEL is 50 micrograms (µg) of lead per cubic meter (m^3) of air. If you are exposed for periods longer than 8 hours, the PEL is reduced proportionally. The action level is 30 $\mu g/m^3$ of air calculated as an 8 hour TWA.

If exposures are over the action level but less than the PEL, your employer must begin to comply with the regulation by implementing a number of provisions of the standard. These include:

- Periodic exposure monitoring
- Biological monitoring
- Employee training.

The purpose of the action level is to establish a lower level of exposure which requires your employer to begin to provide you protection before your exposures go over the PEL. The incentive to the employer is to avoid exposures over the action level and especially over the PEL.

Important points to remember:

PEL = 50 $\mu g/m^3$ of air.

AL = 30 µg/m3 of air.

EXPOSURE ASSESSMENTS

Your employer is required to determine the airborne level of lead you are exposed to in work involving lead. This is termed exposure assessment. Personal air monitoring is required in order to determine your exposure level. Where two or more workers are doing essentially the same task and would likely be exposed to similar lead levels, not all workers need to have their individual exposures determined.

The standard requires three specific exposure assessment actions by your employer.

Initial Assessment

An initial assessment of exposure must be conducted to determine whether workers are exposed over the action level for all work involving lead. Initial Exposure Assessment is conducted as follows:

- One full shift of personal air samples for each job classification in each work area is required.
- Sampling must be representative of workers' regular daily exposure.
- Initial exposure determinations must be based upon the assumption that workers are NOT wearing respirators.
- In specific conditions an employer may use objective historic data instead of doing the initial determination.

An example of objective data would be a contractor that does the same kind of work the same way on every job with the same number of workers and the lead material to which potential exposure might occur has been demonstrated not to result in worker exposures at or above the AL if specific procedures are used.

Based upon the results of the initial assessment the employer must develop and implement a program to comply with the standard to assure that your exposure does not exceed the PEL. If exposures are less than the action level, no further action is required. If exposures are over the action level but less than the PEL, some actions are required. If over the PEL, extensive actions are required.

Periodic Exposure Assessment

If the initial assessment indicates exposures over the AL or the PEL, the employer is required to conduct exposure assessments every six months if the worker exposure is at or above the AL, but below the PEL, or quarterly (every three months) if exposure is above the PEL.

Additional Exposure Assessment

Additional assessments must be made whenever a change in practices, procedures, equipment, personnel, materials, or other factors which could be expected to result in a change in lead exposures to workers occurs.

Protection of Employees During Exposure Assessments

This standard is unique. It recognizes that there are a number of jobs and tasks in construction where exposure to lead will likely be over the PEL, in some cases at very high exposure levels. This is particularly true for work performed on bridges, steel structures, and demolition projects. The standard requires that if a contractor is engaged in any of these "presumed exposure" activities, the workers must be protected by specified measures BEFORE exposure assessments are made. In other words, the contractor cannot assign jobs for these tasks, collect personal samples, wait for results from the lab, and then provide workers protection.

Categories of Presumed Exposure

1. Tasks for which exposures must be assumed over the PEL but less than 10 times the PEL. These include the following activities where lead containing paint or coatings are present:

- Manual demolition of structures (e.g. dry wall)
- Manual scraping
- Manual sanding
- Heat gun application
- Power tool cleaning with dust collection systems
- Spray painting with leaded paint

2. Tasks where exposures are presumed to be greater than 10 times the PEL, but less than 50 times the PEL. These include the following activities where lead-containing paint or coatings are present:

- Rivet busting
- Power tool cleaning without dust collection systems
- Cleanup activities where dry expendable abrasives are used
- Abrasive blasting enclosure movement or removal
- Using lead containing mortar
- Lead burning

3. Tasks presumed to result in exposures over 50 times the PEL. These include the following activities where lead containing paint or coatings are present:

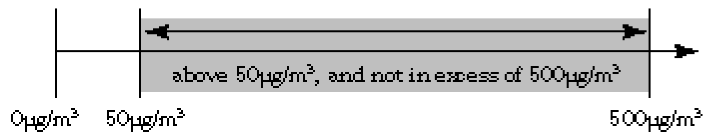
- Abrasive blasting
- Welding
- Cutting
- Torch burning

For all three categories of work tasks with presumed exposures over the PEL, the employer is required, before doing the exposure assessment, to provide:

- Appropriate respiratory protection (Table 1 in standard)
- Appropriate personal protective clothing and equipment
- Changing areas which are free of lead
- Hand washing facilities
- Biological monitoring that measures the amount of lead in the blood prior to or no more than after the second day of exposure
- Training

To better illustrate the three Presumed Exposure Categories, Figure 3-1 provides information for each of the categories, an illustration of the exposure range, and a listing of specific tasks associated with each category.

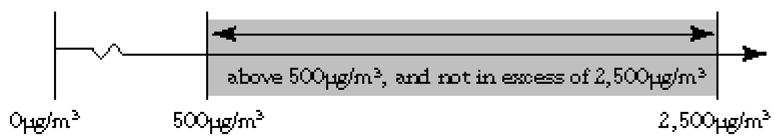
Category 1):
Tasks for which exposures must be assumed above the PEL, and not in excess of 10x the PEL.



Specific tasks associated with Presumed Exposure Category 1 are:

- Manual Demolition of Structures (e.g., dry wall)
- Manual Scraping
- Manual Sanding
- Heat Gun Applications
- Power Tool Cleaning with Dust Collection System
- Spray Painting with Lead Paint

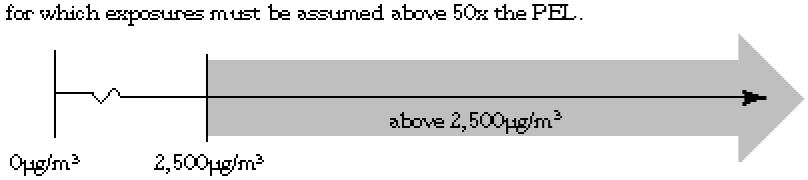
Category 2):
Tasks for which exposures must be assumed above 10x the PEL, and not in excess of 50x the PEL.



Specific tasks associated with Presumed Exposure Category 2 are:

- Using Lead Containing Mortar
- Lead Burning
- Rivet Busting
- Power Tool Cleaning without Dust Collection System
- Cleanup activities where Dry Expendable Abrasives are used
- Abrasive Blasting Enclosure Movement and Removal

Category 3):
Tasks for which exposures must be assumed above 50x the PEL.



Specific tasks associated with Presumed Exposure Category 3 are:

- Abrasive Blasting
- Welding
- Cutting
- Torch Burning

Figure 3-1. OSHA presumed exposure categories.

Employee Notification

The employer is required to notify you in writing, within 5 working days after completion of exposure assessments, of the results which represent your individual exposure. If a coworker wore the personal air monitor and the results of that sample are intended to represent your exposure, you must be notified in writing.

If exposure assessments indicate exposures at or above the PEL, the employer must also notify you in writing of the exposure results and of the corrective actions which are or will be taken to reduce your exposure to below the AL.

The contractor must also allow workers or their designated representatives to observe any lead exposure monitoring of workers that is conducted.

METHODS OF COMPLIANCE

Engineering and Work Practice Controls

The OSHA standard requires that your employer follow certain steps to reduce your exposure to lead. These must be followed in a specified order. For example, your employer cannot just hand you a respirator as a way to reduce your exposure to lead. The employer must first implement engineering and work practice controls to reduce exposures. If these are not sufficient or feasible to reduce exposures to or below the PEL, the employer must continue to use these methods even though you may be required to wear a respirator.

Compliance Program

Prior to the start of a job involving lead exposure, the employer is required to establish and implement a WRITTEN compliance program. That program must address a number of specific items which are outlined in the standard at 1926.62(e)(2). The written program must include the following:

- A description of each activity in which lead is released into the air.
- The procedures that will be used to achieve compliance, including engineering controls.
- Information on the technology considered to meet the PEL.
- Air monitoring results that identify where the lead is being released into the air.
- A schedule for implementing the program.
- The work practices to be used including protective work clothes and house keeping and hygiene facilities.
- Any administrative controls that might be used.
- How contractors on multi-contractor sites will inform workers of potential exposure to lead.

In addition, the compliance program must provide for frequent and regular inspections of job sites, materials, and equipment by a competent person.

Competent Person

The competent person is someone on the job who is capable of recognizing lead hazards and who has the authority to take corrective action to eliminate those hazards. The written program must also be provided upon request to a number of parties including affected workers and their representatives. These written programs MUST be revised and updated every 6 months.

Mechanical Ventilation

When mechanical ventilation is used, it must be evaluated (tested and inspected) to assure that it remains effective in controlling exposures.

Administrative Controls

One method to limit employee exposure to lead is to limit the time during which they are exposed. For example, workers might be assigned work involving lead exposure for only four hours per day. This is referred to as employee rotation. If such administrative controls are used, the employer is required to do the following:

- Maintain records including the names and ID numbers of affected employees.
- Identify the length of time the worker was exposed.
- Record the exposure level the affected worker(s) were exposed.

These steps are taken so that the actual achievement of a rotation schedule approach can be verified.

Respiratory Protection

Respirators must be provided at no cost to workers when:

- Exposure to lead exceed the PEL.
- Engineering controls and work practice controls do not reduce exposures below the PEL.
- An employee requests one.
- As an interim protective measure whenever Presumed Exposure Category Tasks 1, 2, or 3 are performed.

Powered Air Purifying Respirators (PAPR's) must be provided whenever an employee request one IF the PAPR provides sufficient protection for the exposure.

Where respirators are used, the employer MUST HAVE a written respiratory protection program which complies with the OSHA respirator standard under 29 CFR 1910.134. That standard requires fit testing and medical certification that the employee can safely use a respirator, among other requirements.

A respirator selection table is provided in the standard for the purpose of selecting proper respirators based upon the exposure level. (See Appendix).

Protective Clothing and Equipment

The employer is required to provide protective clothing to each employee as follows:

- Exposure to lead exceeds the PEL.
- Workers are exposed to lead which may cause skin or eye irritation.

- As interim protection when performing Presumed Exposure Category Tasks 1, 2, or 3.

Protective clothing and equipment is to be provided at no cost to the employee. Protective clothing and equipment may include coveralls, gloves, hats, shoes, disposable shoe coverings, face shields, vented goggles, or other appropriate protective equipment necessary to protect the exposed employee.

Reusable protective clothing (such as reusable coveralls), must be provided in a clean and dry condition at specific intervals based upon the employees level of airborne exposure to lead. Reusable protective clothing must be provided as follows:

Level of Exposure	Clean, Reusable Protective Clothing Provided...
Less Than (<) 200 μg/m³ Greater Than (>) 200 μg/m³	Weekly Daily

The employer is responsible for cleaning, laundering, disposal, repair, and replacement of such gear.

The employer must also assure that no worker wears contaminated clothing or equipment off the job and that such clothing and equipment is removed after the job only in the change areas provided. NO WORKER should ever wear lead- contaminated clothing off the job. The lead on the clothing will contaminate vehicles and the worker's home, potentially exposing family members to lead.

IT IS NOT PERMISSIBLE to clean protective clothing or equipment using compressed air, shaking, or other methods that release lead into the air.

Housekeeping

The standard requires that all work areas be kept as free of lead accumulation as practicable. High Efficiency Particulate Air (HEPA) vacuums are the preferred method for cleaning. Shoveling and dry or wet sweeping are not permitted unless HEPA vacuuming, has been demonstrated to not be effective. Compressed air can not be used for cleaning unless special ventilation systems are also used to capture the dust generated by that technique. An example is blow-down of blasted metal surfaces inside a containment structure which has been designed to keep dust levels down using special ventilation systems.

Hygiene Facilities

The standard has a number of provisions which address the fact that lead is a health hazard to workers from routes of exposure other than breathing air which has lead dust in it. These aspects of the standard are designed to protect workers from ingesting lead and from tracking lead around the job site and into their homes. Included are:

- Prohibitions
- Changing Areas
- Showers

- Eating Facilities
- Hand wash facilities

Prohibitions

In any work area with airborne lead levels over the PEL, workers are prohibited from smoking, eating, drinking, and applying cosmetics. Food, drinks, and tobacco products are not even allowed in such work areas.

Clean Changing Areas

Where workers are exposed over the PEL, or where workers are performing presumed exposure tasks, clean change areas must be provided. These must include separate storage areas for protective clothing and equipment and for street clothes. The employer is responsible for assuring that workers do not leave the job wearing contaminated clothing.

Showers

Again, where exposures exceed the PEL the employer must provide and assure the use of showers for exposed workers. Showers must be provided "where feasible." OSHA has developed additional guidelines which better define what "feasible" means. In practice, portable shower facilities are usually provided for large lead related projects. The employer must provide soap and clean towels for workers having to shower at the end of the work shift. It is important to carefully wash the hair as this is a major collection point for lead dust and debris. Where showers are not provided, workers should change into clean street clothes after washing and shower as soon as they arrive home.

Eating Facilities

Lead free eating areas or lunchroom facilities must be provided for workers exposed over the PEL. Workers using these facilities must wash their hands and face prior to eating, drinking, smoking or applying cosmetics, and they must not enter the area wearing contaminated clothing.

Hand Wash Facilities

Employers must provide hand- washing facilities for workers exposed to lead. Where showers are not provided, the employer is required to assure that all exposed workers use the hand wash facilities to wash their hands and face before leaving the job site.

MEDICAL SURVEILLANCE

Medical surveillance is an important provision of the OSHA standard. This is because the lead which is breathed or ingested ends up in the blood. Therefore, the medical surveillance program centers around the determination of the level of lead in the worker's blood. When your blood lead level increases, this indicates that the protective measures being used on the lead job may not be adequate. The medical surveillance requirements of the standard are somewhat complex, but the following covers the highlights which are important to you.

Initial Surveillance

Initial surveillance is a determination of your blood lead level. This is often referred to as "biological monitoring." The initial determination is required if you are exposed at or above the action level on any one day, or you are engaged in lead work covered by any of the three presumed exposure category work tasks. Your employer must have your blood lead level determined prior to, or no later than, after the second day of lead exposure. This is a critical test as it establishes your base line blood lead level. Any future blood lead level tests will then indicate whether you have been overexposed. This is because any increase in your blood lead level over the level you had when you started the job will indicate that you have been overexposed. All labs testing blood for lead levels must be approved by OSHA.

Biological monitoring is also required every 2 months during the lead exposure job for the first 6 months, and every 6 months after that, for workers exposed to lead at or above the action level for more than 30 days annually. IF YOUR BLOOD LEVEL increases to, at, or above 40 micrograms per deciliter (µg/dl), biological monitoring must continue every 2 months until your blood lead level drops below 40 µg/dl.

If two blood lead levels taken no more than two weeks apart are at or above 50 µg/dl, you qualify for Medical Removal Protection, (MRP). MRP will be reviewed later, but if you are covered by the MRP provisions, your blood lead level will be determined every month until the lead level drops to 40 µg/dl or below.

Your employer is required to notify you in writing of the results of your blood lead test within 5 working days of receipt of the data from the lab. If your blood level exceeds the MRP trigger level, your employer must advise you of the provisions of the MRP protections as well.

Medical Examinations

Medical examinations involve an examination by a licensed physician in accordance with criteria established in the standard. The employer must make available medical exams to those workers exposed at or above the action level for more than 30 days in any consecutive 12 months in accordance with the following schedule:

- Annually for each worker whose blood lead level within the past 12 months was at or above 40 micrograms per deciliter.
- When a worker has signs or symptoms associated with lead poisoning.
- When a worker wants medical advice concerning the effects of current or past lead exposure on his or her ability to have healthy children.
- When a worker has difficulty breathing when using a respirator.

- When a worker is pregnant.
- If medically appropriate for workers removed from lead exposure due to a health risk or following a final medical determination.

Medical examinations must be made available to you at no cost and at reasonable times and places. Your employer is entitled to receive ONLY the physician's written medical opinion which addresses whether the worker has any medical condition that could put the worker's health at increased risk from exposure to lead. The employer must provide you a copy of this medical opinion. The physician can NOT reveal any other information about you which is not related to lead exposure to your employer.

There are other provisions in the standard with regard to medical surveillance. These include, for example, your right to have a second medical opinion and examination at the cost of the employer if you disagree with the findings of the original physician. This process is called "multiple physician review" in the standard.

MEDICAL REMOVAL PROTECTION (MRP)

If your blood lead level is at or above 50 µg/dl, your employer must provide another blood lead test within two weeks. If the second test is also at or above 50 µg/dl, you qualify for Medical Removal Protection (MRP). This means that the employee must be removed from any job with lead exposures at or above the action level (30µg/m³ until your blood lead level drops below 40 µg/dl in two consecutive blood tests. If the employer does not have any other job for you which does not involve lead exposure, the employer must pay you MRP benefits which maintain your total earnings, seniority, and other employee rights and benefits for a period of up to 18 months or until your blood lead drops below 40 µg/dl (in two consecutive BLL tested). If your employer moves you to a non-lead exposed job, your earnings, seniority and benefits cannot be reduced. These protections apply for as long as the job you were performing continues.

If you file for workers' compensation (while on MRP), the amount the employer must pay you is reduced by the amount of your compensation payment.

The MRP section of the OSHA Standard is much more detailed than covered here, but this covers the basic protections which you are guaranteed if you are overexposed to lead on the job. If you are covered by the MRP provisions, you must agree to have a blood lead determination made once per month until your blood lead level drops below 40 µg/dl or the 18 month period ends.

EMPLOYEE INFORMATION AND TRAINING

The standard requires that your employer provide you training prior to the time of job assignment where you are subject to exposure to lead at or above the action level for any one day or where you may be exposed to lead compounds which may cause skin or eye irritation. Training is required annually for each employee subject to exposure to lead at or above the action level for any one day. The standard specifies the minimum elements which must be covered in the training program. No minimum training hours are specified, however. This training program for Laborers exceeds the requirements of the standard for the basic materials to be covered. The employer must also cover the engineering controls and work practices to be used on the specific job and the written compliance program. This is site-specific training. The standard also requires training under OSHA's Hazard Communication Standard, 29 CFR 1926.59.

The EPA has issued regulations requiring the training and certification of workers, supervisors, and contractors engaged in residential lead work. Training requirements for lead related work on bridges, steel structures and commercial buildings are currently being developed, although no anticipated time of release has been stated.

SIGNS

The employer is required to post signs in each work area where employees' exposure to lead is above the PEL which reads:

WARNING LEAD WORK AREA POISON NO SMOKING OR EATING

RECORDKEEPING

Your employer is required to establish and maintain accurate records covering a number of matters including:

- Exposure monitoring.
- Medical surveillance.
- Medical removals.
- Objective data used to establish the basis for avoiding the requirement to conduct initial exposure monitoring.

All of these records must be available to you, whether a current or past employee, and your designated representative, among others. The employer may not charge the cost of copying the materials. All of these records are available to you under OSHA's "Access to Employee Exposure and Medical Records" regulation in 29 CFR 1926.33.

It is important that you request IN WRITING that your records be sent to someone you designate, such as your family physician, when you leave the job. Figure 3-2 illustrates a sample authorization letter for release of employee medical record information to a designated representative.

I, ________________________ (full name of worker/patient), hereby authorize________________________ (individual or organization holding medical records) to release to__________________ (individual or organization authorized to receive the medical records) the following medical information from my personal medical records:

____

____

(Describe generally the information desired to be released)

I give my permission for this medical information to be used for the following purpose:

____

____

but I do not give permission for any other use or re-disclosure of this information.

(Note: Several extra lines are provided below so that you can place additional restrictions on this authorization letter if you want to. You may, however, leave these lines blank. On the other hand, you may want to (1) specify a particular expiration date of this letter (if less than one year); (2) describe medical information to be created in the future that you intended to be covered by this authorization letter; or (3) describe portions of the medical information in your records which you do not intend to be released as a result of this letter.

____

____

____

____

____

Full name of Employee or Legal Representative

____

Signature of Employee or Legal Representative

____

Date of Signature

Figure 3-2. Sample authorization letter.

APPENDICES

There are a number of appendices to the standard that provide more information on procedures and methods to comply with the standard. The appendix provides an important discussion of the health hazards of lead. You should take the time to read that appendix which is provided in this training manual.

U.S. ENVIRONMENTAL PROTECTION AGENCY

The U.S. Environmental Protection Agency (EPA) has responsibility for environmental issues including air pollution, water pollution, solid waste disposal, and drinking water standards. The US EPA frequently works closely with state agencies who enforce state regulations which are at least equivalent to federal standards. Additionally, the US EPA has regulatory responsibility over the following areas:

Air

EPA has established lead as a national primary pollutant with an ambient air quality standard for lead of 1.5 $\mu g/m^3$, averaged over a calendar quarter. In addition, EPA has an ambient air standard for particulate matter, for very small particles less than 10 microns in size (called PM-10) that can't exceed 150 $\mu g/m^3$ averaged over a calendar quarter. Work on bridges, steel structures, and demolition may cause an air or soil problem with lead particles from uncontrolled ventilation from the work area. HEPA filtration of air discharged to the outside is recommended.

Waste

EPA has designated lead and lead compounds (not otherwise specified), as hazardous constituents of solid waste. EPA lists reportable quantities (RQs) for lead and several of its compounds at one pound.

Under a federal law called the Resource Conservation and Recovery Act (RCRA), the US EPA has been given the responsibility for regulating hazardous waste. The EPA classifies a waste as hazardous based on whether it's specifically listed as a hazardous waste or if the waste has hazardous characteristics, such as toxicity or corrosiveness.

Waste generated from construction work performed on bridges, steel structures, and demolition can be classified as hazardous waste. For example, spent abrasive blasting material that contains lead paint may be a waste that EPA considers as hazardous. For wastes containing lead, the EPA requires that a specific test be performed on the waste, the Toxicity Characteristic Leaching Procedure or TCLP, to determine how much lead is leached out of the waste. If the waste leaches 5 milligrams of lead per liter (5 mg/liter) or more using the TCLP test, the waste is considered to be hazardous and must be handled, stored, and disposed of following EPA regulations for hazardous wastes.

When conducting lead work on bridges, steel structures, and demolition, the contractor may become a hazardous waste "generator" under the EPA regulations. Each contractor must determine if the waste he/she is generating from the work is a hazardous waste and how it is to be disposed of properly.

US CONSUMER PRODUCT SAFETY COMMISSION

The U. S. Consumer Product Safety Commission (CPSC) is responsible for establishing and enforcing Federal Safety Regulations covering consumable items for general public use, including the paint that a contractor would be able to use to repaint an abated surface. In 1977, the CPSC limited lead in most paints to 0.06%.

Federal regulations include specific monitoring and surveillance requirements which are dictated by blood lead level results. The flowcharts illustrated in Figures 3-3 and 3-4 summarize the medical surveillance requirements under the OSHA lead

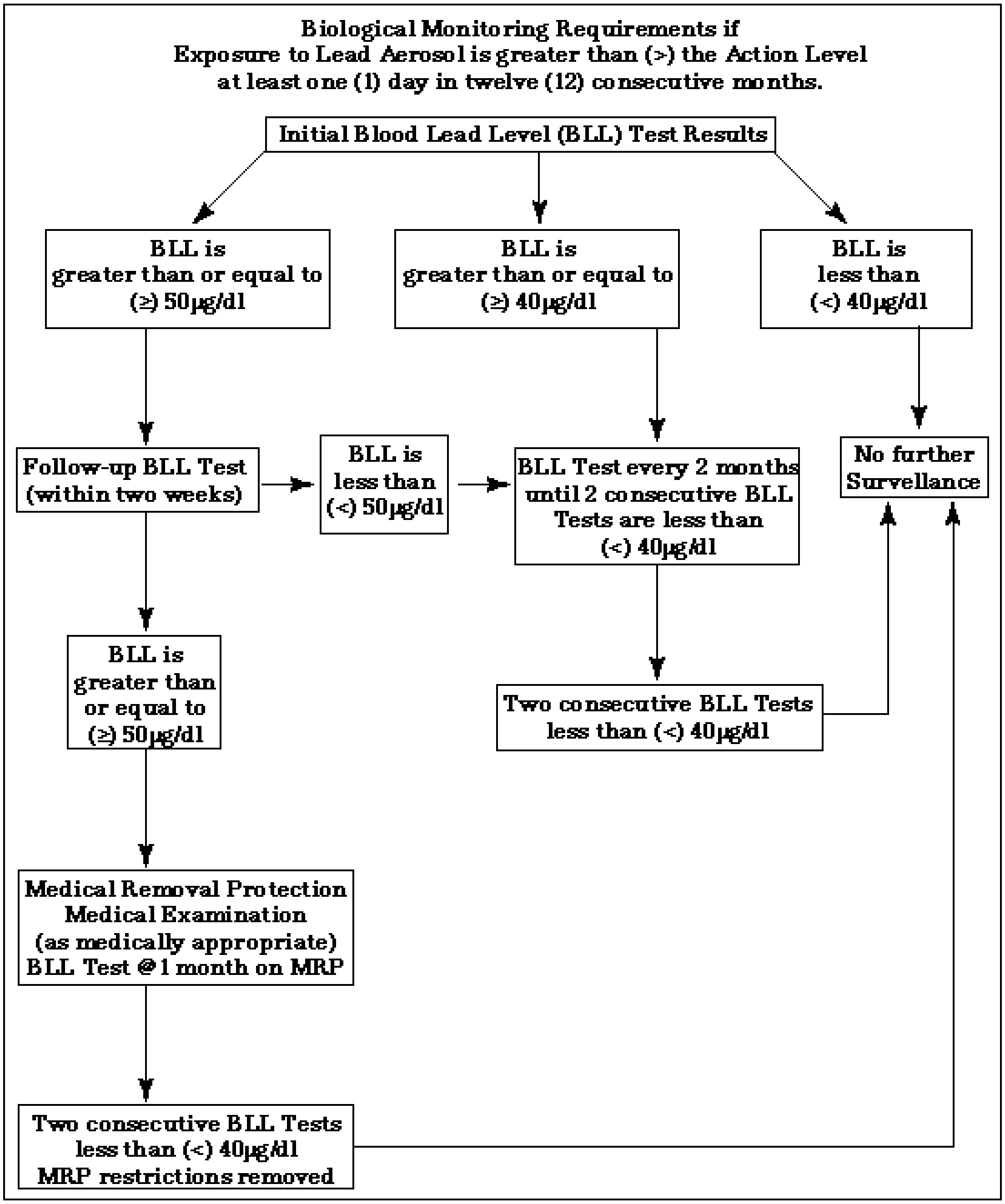


Figure 3-3a. Medical Surveillance flowchart I.

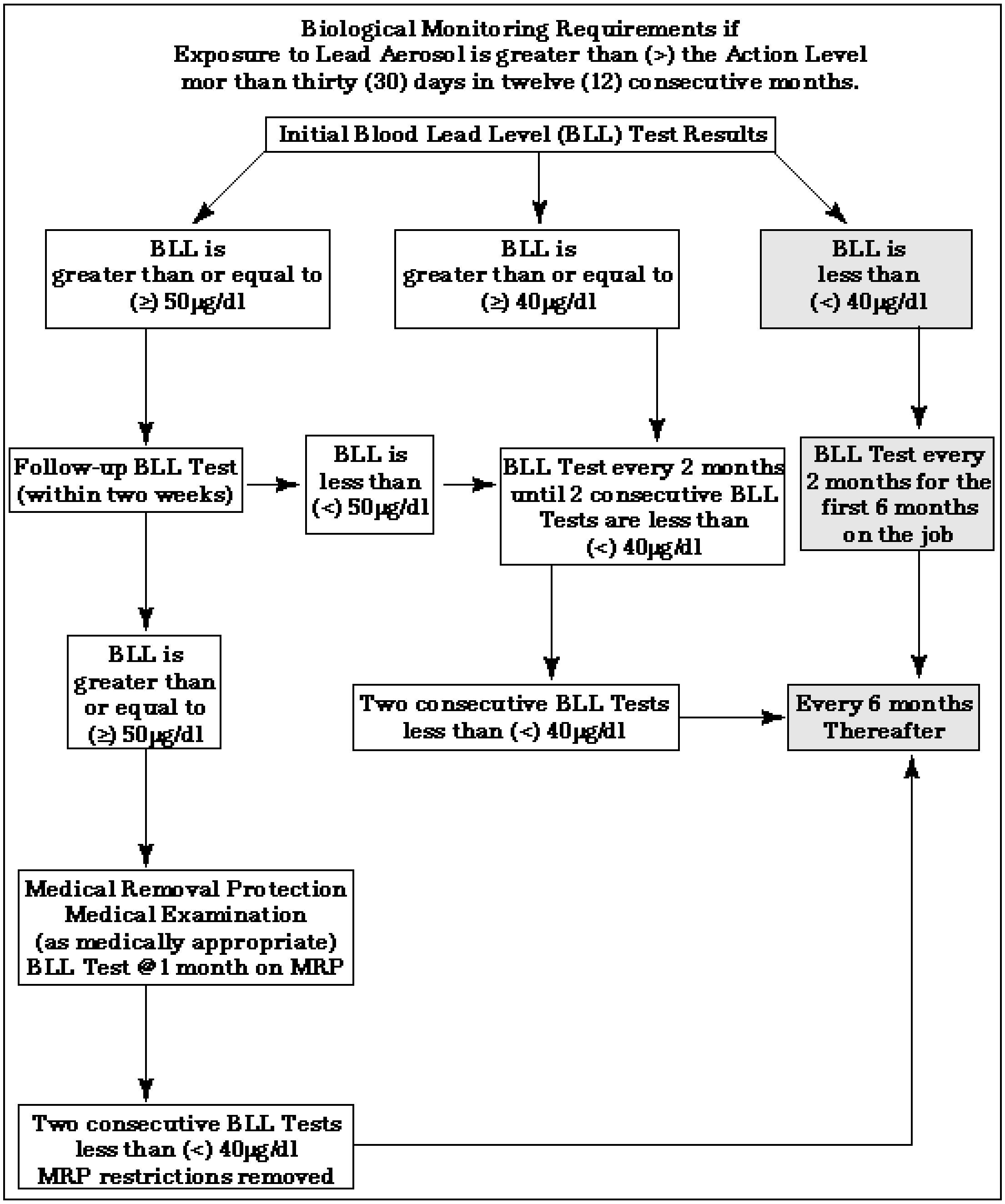


Figure 3-3b. Medical surveillance flowchart II.

ASSIGNMENT SHEET

1. Write out the following abbreviation

   EPA ____

   OSHA ____

   PEL ____

   AL ____

   MRP ____

   CPSC ____

2. List four items an employer must do if you are exposed to lead and covered under the Interim Lead Standard for Construction (OSHA 1926.62).

   1) ____

   2) ____

   3) ____

   4) ____

3. Define Medical Removal Protection.

   ____

   ____

4. Complete the following table.

Presumed Exposure Category	Presumed Exposure Range	Specific Tasks Associated with Presumed Exposure Category
1		
	Above 50 µg/m³, not in excess of 500 µg/m³	
		Abrasive Blasting, Welding, Cutting, Torch Burning

5. List the Action Level and Permissible Exposure Limit for lead under the OSHA Interim Lead Standard for Construction (29 CFR 1926.62).

Action Level ______________________________

Permissible Exposure Limit ______________________________

6. List three practices that are prohibited (by OSHA) in a lead exposure area.

   1) ______________________________

   2) ______________________________

   3) ______________________________

7. How often must an employer test the blood lead levels of employees who are exposed to lead above the Action Level for 30 days or more per year? Assume that all tests result in blood lead levels below 40 µg/dl.

   ____

   ____

   ____

PERSONAL PROTECTIVE EQUIPMENT

TRAINEE OBJECTIVES

After completing Section 4, you will be able to:

1. Define the following terms:
    2. Maximum use concentration
       Protection factor
       Quantitative fit test
       Qualitative fit test
       Tested and certified

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

3. List the PPE used by lead abatement workers.

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

5. List the seven limitations of a half-face APR.

6. List the six limitations of a full-face APR.

7. List the four limitations of the full-face SAR.

8. List the two limitations of SCBAs.

INTRODUCTION

Personal protective equipment (PPE) is any protective clothing or device used to prevent contact with, and exposure to, hazards in the work place. Hazards may be chemical or nonchemical although lead exposed workers are most concerned with respiratory PPE. Examples of PPE include respirators, gloves, protective suits, boots, hard hats, and safety glasses.

PPE is critical to the safe performance of lead abatement work. Therefore, workers need an appreciation of the types of PPE, their limitations, and what goes into the selection process. The PPE issue is made more complicated because no one type protects against all exposure situations. As a result, there are many types of protective gear. Choosing the correct type requires that the industrial hygienist have a detailed knowledge of the chemical exposure(s) at hand. This section discusses the following areas of PPE:

- Respirators
- Fall protection systems

Respiratory Protection

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

1. Air purifying - Filters are used to purify the air
2. Atmosphere supplying - A supply of clean air is provided from a tank or hose

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

Protection Factors

The key to understanding respirator protection is to realize that all respirators leak to a certain degree. The amount of leakage depends on how well the facepiece seals to the face. A leak in the facepiece means that contaminated air can enter the facepiece. The act of inhaling creates negative air pressure inside the facepiece that results in a slight suction effect. The suction can draw in contaminated air. These leaks compromise the protection given by the respirator. Breathing contaminated air can lead to adverse health effects depending on the type and amount of chemical.

Respirators are tested for leakage by measuring the contaminant levels both outside and inside the respirator. Using the ratio of these two measurements, a PF is assigned. A PF is based on the assumption that the respirator is working properly, is worn correctly, and fits the wearer. Respirator PFs range from 5 to 10,000. **The lower the PF, the lower the protection. The higher the PF, the higher the protection.** Figure 4-1 shows the calculation for determining the PF.

The PF is calculated by dividing:

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

$$PF = \frac{500\ \mu g/m^3 \text{ (concentration of lead outside the respirator)}}{50\ \mu g/m^3 \text{ (concentration of lead inside the respirator}}$$

$$PF = 10$$

Figure 4-1. Calculating the protection factor.

The goal of a respirator is to reduce the amount of hazardous chemical inside the mask to below the Occupational Safety and Health Administration (*OSHA*) permissible exposure limit (*PEL*). Respirators must be chosen to ensure that workers are never overexposed while wearing the respirator. The practical application of PF for the asbestos worker can be summed up as: How much of the outside contaminant level is reduced by the respirator? Examples follow:

- A respirator with a PF of 10 reduces a worker's exposure by 10 times, or to 1/10 of the outside level. Therefore, if the contaminant level outside the respirator is 100 $\mu g/m^3$, the contamination inside the respirator is 10 $\mu g/m^3$. Should the PEL for the contaminant be below 10 $\mu g/m^3$, the worker is overexposed. A PF of 10 means that the respirator can only be used in exposures up to 10 times over the PEL.

- A respirator with a PF of 10,000 reduces the worker's exposure by 10,000 times. Concentration inside the respirator may be 1/10,000 of the outside level.

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

Maximum Use Concentration

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

The MUC is calculated by multiplying PF times PEL. Figure 4-2 gives an example of calculating the MUC for nitric acid.

Calculate the MUC of nitric acid:	
MUC = PF x PEL	
PEL for nitric acid	= 2 parts per million (ppm)
PF of half-face respirator	= 10
MUC = 2 PPM x 10	
= 20 PPM	
A half-face respirator cannot be used in atmospheres with a nitric acid concentration greater than 20 PPM	

Figure 4-2. Calculating the MUC for nitric acid.

AIR PURIFYING RESPIRATORS

Air purifying respirators (*APRs*) clean the air a worker breathes by removing or filtering a contaminant from the air before it enters the wearer's lungs. APRs have two components-the facepiece and the filter or cartridge. When a worker inhales, contaminated air is pulled into the respirator through a filter or cartridge attached to the facepiece. The filter or cartridge removes the contaminant from the air before it enters the inside of the respirator through the inhalation valve. When the wearer exhales, air from the lungs reverses the airflow through the facepiece and out a separate valve called the exhalation valve.

Negative Pressure Respirators

APRs are commonly called negative pressure respirators. They depend on lung power to pull the air through the filters. The suction created when a worker inhales draws air into the respirator. This suction creates a momentary negative pressure. During inhalation, the negative pressure brings contaminant's into the facepiece through leaks and improper seals. During exhalation air is blown out and a positive pressure is created in the facepiece. It's important to remember that negative pressure respirators must only be used if the oxygen level in the work place is above 19.5%.

Disposable Paper Masks and Quarter Masks

Many workers are familiar with the disposable paper masks. They are the throwaway type, and do not seal to the face well enough to provide a good fit. Laboratory tests done with mannequins show PFs of 5 to 10. However, studies done under actual work conditions show even lower PFs. The leakage for this type of mask is too severe. Furthermore, the paper of a disposable mask is only effective for large-particle dusts. Gases, vapors, fumes, and fine dusts, such as asbestos, may pass right through the paper. These masks are not to be used for asbestos abatement operations.

The quarter mask is normally a rubber mask, which fits from the top of the nose to the top of the chin. It uses cloth or cartridge filters. The PF is rated at 5. This type of mask it is not to be used for asbestos abatement work.

Half-Face APRs

The half-face APR is made of rubber or plastic. It fits from the top of the nose to under the chin. Figure 4-3 shows a typical half-face APR.

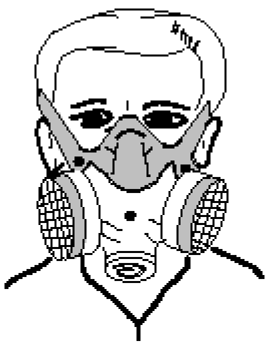


Figure 4-3. Half-face air-purifying respirator.

A half-face APR uses one or two filter cartridges attached to the facepiece to filter the air. The fit given by the respirator rates a fairly low PF of 10. These respirators can be used in some situations, but the industrial hygienist must be confident in his or her knowledge of the level of asbestos exposure that will occur, and how high the levels can potentially get.

Other limitations of the half-face APR are:

- No eye protection - The respirator does not cover the eyes. Goggles or face shields must be used.
- Cartridge life problems - The filter has a limited ability to remove chemical contaminant's. When the saturation point is reached, chemicals begin to pass through the filter. This condition is called breakthrough. Some chemicals have poor warning properties so a worker will not notice any chemical smell when breakthrough occurs. This situation can lead to serious exposure problems. As a result, the half-face APR cannot be used for chemicals with poor warning properties. Some filters have end of service life indicators (ESLI), that change color when a filter is used up. However, few indicators have been successfully developed and most are for specific chemicals only.
- Cartridge efficiency problems - There are many types of organic solvents, but only one type of organic solvent filter. Studies show that while this filter is very efficient for some solvents, it allows other solvents to pass through quickly. For example, the organic vapor filter lasts 143 minutes in an atmosphere with a concentration of 1,000 PPM of 1-nitropropane. But at 1,000 PPM of ethyl

chloride, the filter only lasts 5.6 minutes. Therefore, the half-face APR and filter are not used for solvents that have rapid breakthrough. However, not all solvents have been tested.

- Oxygen limitations - The half-face APR can only be used when sufficient oxygen is present in the work atmosphere. Normal breathing air contains about 21% oxygen. It can be less in confined areas with other chemicals present.

- Not suitable for areas of unknown chemicals or levels - The protection offered by this respirator is limited, therefore, it cannot be used for unknown situations. The levels might exceed 10 times the PEL or different chemicals might go right through the filter to cause health effects. Specific cartridges are manufactured to protect against specific chemicals and may not be used in some mixed chemical atmospheres.

- Not suitable for concentrations that are immediately dangerous to life or health (IDLH) - Under no circumstances should an APR be used in an IDLH atmosphere. For most chemicals this is not an issue, because the MUC is lower than the IDLH level. But there are exceptions. For some chemicals, the IDLH is lower than the MUC and the respirator can not be used if the level approaches the IDLH level.

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

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

Half-face respirators are the minimum type used for asbestos abatement work.

Table 4-1 is a list of some chemicals that can't be safely protected against by APRs. Table 4-2 lists general MUCs for chemical cartridges that have hazardous breakthrough problems.

Table 4-1. Chemicals not suited for air purifying respirators.

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

Methyl chloride	Toluene diisocyanate

Table 4-2. Maximum use concentrations for chemical cartridges with hazardous breakthrough problems.

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

Full-Face APRs

A full-face APR is made of rubber or plastic. It covers the whole face, starting at the forehead, down over the temples and the eyes, and under the chin (Figure 4-4). The full-face APR has a PF of 50 because it's easier to get a good seal across the forehead than across the nose. Also, the respirator is held more securely in place because it has a harness instead of straps. The full-face APR uses the same types of filters as the half-face APR, so it also carries the same limitations. It does protect the eyes, although it has a tendency to fog up.

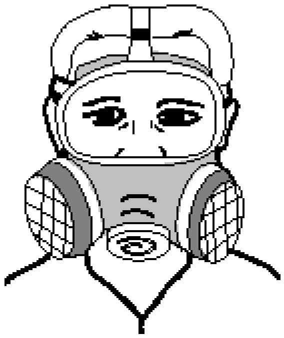


Figure 4-4. Full-face air-purifying respirator.

Some full-face APRs can use larger chin, chest, or back-mounted canister-type filters. These filters are larger, and have fewer limitations. There are several filters available in larger sizes for full-face APRs that are not available for half-face APRs. Since canisters are larger than cartridges, they have higher capacities. Even though full-face APRs protect more than half-face APRs, they still do not offer enough protection to be used in IDLH conditions.

Powered Air Purifying Respirator

The powered air purifying respirator (*PAPR*) uses the same type of facepiece and filters as the full-face APR (Figure 4-5). However, the full-face APR is a negative pressure APR and the PAPR is a positive pressure APR. The PAPR uses a small lightweight battery-operated blower to draw air through filters and into the facepiece. This makes it more comfortable to use because less work is required to breath. Also air is blown across the face to provide some degree of cooling. Because the PAPR seals the face in the same manner as the full-face negative pressure APR, the protection factor assigned by OSHA (for exposure to lead) is 50.

Figure 4-5. Powered air-purifying respirator.

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

1. Weak batteries cause the fan motor to slow down. The batteries are designed to last a full shift, and then require a full 8-hour charge. PAPR units come with a small flow meter that enables the worker to test the air flow and thus the battery charge.

2. Under heavy work conditions a worker can use more air then the PAPR provides, creating negative pressure in the mask. This condition is called *over breathing* a PAPR. When overbreathing a PAPR occurs, the level of protection provided by the respirator will be reduced.

Some PAPRs have loose-fitting hoods and helmets instead of face masks. While these hoods are comfortable, they provide less protection. OSHA assigns a PF of only 25 for loose-fitting PAPRs.

Filtering Devices

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

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

Particulate Filters

Particulate filter respirators use a filter made of a fibrous material to capture contaminant particles before the air reaches the wearer's lungs. The particles are pulled through the filter as the worker inhales, and become trapped by the fibers of the filter. Particulate filter respirators are used for protection against particles of dusts, fumes, and/or mists. Typical examples include welding fumes, oil mists, silica,asphalt fumes, and asbestos.

42 CFR Part 84 for Particulate Filters

Respirator certification regulations 30 CFR 11 were first promulgated in 1972 and are commonly referred to as Part 11. Since 1972 new research, testing, and advances in technologies have required that changes be made in the certification regulations. NIOSH will be revising all of the certification requirements for all classes of respirators. These changes will take place in modules. The first change is the certification requirements for non-powered, air-purifying particulate-filtering respirators. Modules for all respirators will eventually be revised, but the process isn't expected to be completed for many years.

In July of 1995, the certification requirements in the Part 11 standard were re-titled as 42 CFR 84 or Part 84. Since the effective date of the Part 84 standard, July 10, 1995, NIOSH will only approve new non-powered, air-purifying particulate-filter respirators based on Part 84 performance testing procedure. Manufacturers may still produce and sell the old filters until July 10, 1998.

There are two changes in the particulate filter labels. The changes are listed below:

1. A new sequence of approval numbers will appear on the label for non-powered, air-purifying particulate filters only (TC 84A-XXXX). All other types of respirators (PAPRs, SCBA, etc.) will continue to use the old sequence since there's no change in the testing requirements for any other class of respirators.

2. The approving agencies on the new labels are NIOSH and the Department of Health and Human Services (*DHHS*). All other types of respirators will continue to list NIOSH and Mine Safety and Health Administration (*MSHA*) as the approving agencies. The difference between the labels will help workers to distinguish between Part 11 and Part 84 filters.

Approval labels are normally found on the respirator box, cartridge box, or in the booklet supplied with the respirator. Figures 4-6 shows the label for MSHA approved respirators, and Figure 4-7 shows the label for non-powered, air-purifying particulate filters.

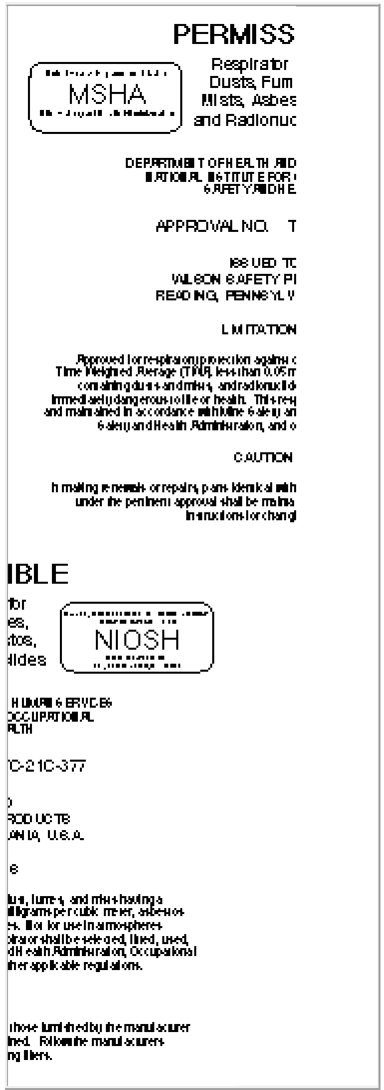


Figure 4-6. NIOSH Approval label showing MSHA as an approving agency.

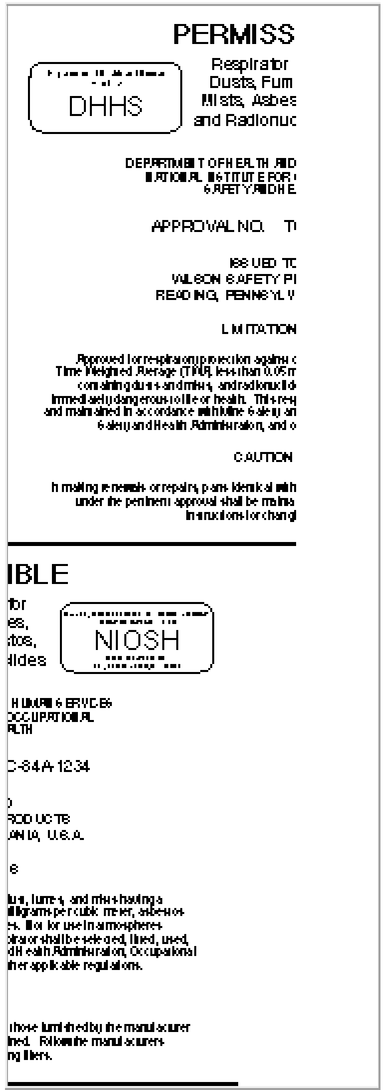


Figure 4-7. Label for non-powered air-purifying particulate filters with new approval numbers and DHHS as approving agency.

Particulate Filter Efficiency

Particulate filters are not designed to be 100% efficient in removing particulates from the air. It would be too hard for a worker to pull air through the filters when inhaling. Filters are manufactured to create maximum filter efficiency while keeping the resistance to breathing low. As contaminated air is drawn through the filter, the particles are captured by the filter, plugging up the holes between the fibers of the filter. This increase breathing resistance for the wearer.

Particulate filter efficiencies are classified into two groups, high efficiency and lower efficiency. High efficiency filters are capable of capturing 99.97% of particles 0.3 micrometers or larger in diameter from air pulled through the filter. Filters of this type are commonly called high efficiency particulate air (*HEPA*) filters. HEPA filters are used for dusts, fumes, and mists having an exposure limit less than 0.05

milligrams per cubic meter of air (0.05 mg/m^3). Particulates with exposure limits this low are the most hazardous to workers' health, which explains why high efficiency filters are to be used. For example, HEPA filters must be used for exposures to asbestos or lead.

Lower efficiency filters are less efficient than HEPA filters and capable of capturing approximately 99% of dust, fume, and mist particulates 0.3 micrometer or larger in diameter . Lower efficiency filters are used for particulates that have exposure limits greater than 0.05 mg/m^3 . These substances are not as hazardous to the health of exposed workers.

Particulate Filter Classification

The new Part 84 regulation creates nine classes of particulate filters. The nine classes are made up of three levels of filter efficiency and three categories of resistance to filter efficiency degradation. The three levels of efficiency are 95%, 99%, and 99.97%. The three categories of resistance are labeled N, R, and P, respectively.

Each filter series must pass a test using a particle with a diameter of 0.3 microns. (A particle that is 0.3 microns can penetrate into the deepest parts of the lungs and cause the most damage.) All three classes of filters are limited in that they must be replaced whenever there is a hygiene concern, damage, or increased breathing resistance detected by the wearer.

N Series The N series is tested against sodium chloride (NaCl) and is used with water-based particulates. It's not resistant to oil and cannot be used in an atmosphere that contains an oil or an oil-based particulate. An N series filter can be used for more than one work shift as long as there are no problems with hygiene, damage, or breathing resistance.

R Series The R series is tested with an oil called dioctyl phthalate (DOP) and is used for filtering any solid or liquid particles. It's resistant to oil, but not oil proof. Therefore, an R series filter has a limited use time if used in an environment containing an oil mist or oil-based particulate. It can be used for one 8-hour shift or a combined total of 8 hours. However in an oil-free environment, the R series filter can be used for an extended period of time.

P Series The P series is also tested with DOP and is used for any solid or liquid particles, both oil-based and non-oil-based. It is oil proof. So a P series filter can continue to be used as long as a worker has no breathing problems.

An easy way to remember the filter series is:

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

There are three filter efficiencies associated with each of filter series. The minimum efficiency levels are 95%, 99%, and 99.97%. These efficiency levels are identified by the following designations:

- Filters with N95, R95, and P95 designations are certified as having a minimum efficiency of 95%. The new series of 95% efficiency filters replace the old dust/fume and dust/fume/mist filters.

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

- Filters with N100, R100, and P100 designations are certified as having a minimum efficiency of 99.97%. These filters replace the HEPA filters under the old certification standard. Unlike the old HEPAs, both the N100 and R100 have limitations associated with them-no oil and oil exposure for one shift only, respectively. The only filter that is directly related to the old HEPA filter is the P100. The P100 filter is the only filter that will keep the familiar magenta color.

Table 4-3 summarizes the nine classes of particulate filters. Figure 4-8 illustrates the decision process for choosing the appropriate filter.

Vapor and Gas Removing Cartridges and Canisters

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

Table 4-3. Nine classes of particulate filters (three levels of efficiency and three categories of resistance).

Filter Series	Filter Designations	Minimum Efficiency	Testing Agent	Service Time
N-Series	N100	99.97%	NaCl	Non-specific
		99%	NaCl	Non-specific
		95%	NaCl	Non-specific
R-Series	R100	99.97%	DOP	One Shift
		99%	DOP	One Shift
			DOP	One Shift
P-Series	P100	99.97%	DOP	Non-specific
	P99	99%	DOP	Non-specific
	P95	95%	DOP	Non-specific

While particulate filters are effective for nearly all types of particles, gas and vapor removing cartridges and canisters are designed to protect against specific individual contaminant's. Examples include carbon monoxide, ammonia gas, or combinations of gases and vapors, such as acid gases or organic vapors.

Contaminant's are removed as inhaled air enters the cartridge or canister and passes through a granular material called a sorbent. The sorbent absorbs contaminant's from the air, and provides protection to the wearer from the toxic effects of the gas or vapor.

Materials used as sorbents include activated charcoal, silica gel, and various mixtures of specific chemicals that will capture the contaminant. Initially a gas and vapor sorbent is 100% efficient in capturing a contaminant. As the sorbent is used up, the efficiency decreases. When the sorbent is exhausted, the contaminant passes completely through the sorbent and into the facepiece where it is inhaled by the wearer. This loss of capturing efficiency is opposite to particulate filters which become more efficient as particles collect on the filter.

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

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

Cartridges or canisters are designed for either one specific type of gas or vapor, or a combination of gases and vapors together. In addition, some cartridges and canisters are manufactured to protect against both gases and vapors, as well as particulates by combining particulate filters with sorbent materials. When filters are combined with gas and vapor sorbents, the filter is located in the inlet side of the cartridge. It is either built into the cartridge itself or held to the outside of the cartridge by a snap-on cover.

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

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

Only chemical cartridges are available for these additional substances:

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

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

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

A color coding scheme has been established to identify the contaminant's that a gas and vapor canister or cartridge protects against. The color coding is assigned to either individual contaminant's or combinations of contaminant's as shown in Table 4-4.

When the sorbent becomes exhausted or used up, breakthrough will occur. Warning signs include odor, taste, or throat irritation. If the wearer notices any warning signs, follow these steps:

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

Gas and vapor cartridges have short useful service times. Therefore, it is recommended workers discard their cartridges or canisters at least daily, even if no odor, taste, or irritation is detected. Some canisters are designed for use against substances with poor warning properties (no odor or taste). These canisters have end of service life indicators (*ESLI*s) that show the canister is exhausted and needs to be replaced. For example, cartridges used for mercury have ESLIs because mercury has poor warning properties that are not readily noticed by a worker being exposed.

Table 4-4. Contaminant color coding.

Atmospheric Contaminant	**Assigned Color**
Acid Gases	White
Organic Vapors	Black
Ammonia Gas	Green
Carbon Monoxide Gas	Blue
Acid Gases and Organic Vapors	Yellow
Acid Gases, Ammonia, and Organic Vapors	Brown
Acid Gases, Ammonia, Carbon Monoxide, and Organic Vapor	Red
Other Vapors and Gases not listed above	Olive
Radioactive Materials (except Tritum and Noble Gases)	Purple (magenta)
Dusts, Fumes, and Mists (other than radioactive materials)	Orange

ATMOSPHERE SUPPLYING RESPIRATORS

There are two types of atmosphere supplying respirators -air line respirators and self-contained breathing apparatus (*SCBA*).

Both types of respirators supply clean breathable air to the wearer and do not depend on filters. With an air line respirator, air is delivered by a hose connected to a compressor. The compressor is equipped with a filtering system that purifies the air. The air for an SCBA is contained either in a compressed air tank or cylinder. The air in the tank or cylinder is under pressure. Regulators are used to reduce the pressure and control the flow of air into the facepiece.

There are two types of regulators:

- Demand flow
- Pressure demand

Demand Flow vs. Pressure Demand Regulators

A demand flow regulator uses the suction force of inhalation to open the regulator valve and let air flow into the facepiece. In other words, when the worker "demands" the air, he or she gets it. When the wearer exhales, the flow of air into the facepiece stops. The advantage of the demand flow regulator is that the air supply is not wasted, so the time allowed by the tank is maximized. The disadvantage is that the regulator depends on negative air conditions during inhalation. Because of this, the PF for demand type atmosphere supplying respirators is only 50.

Pressure demand regulators are similar to demand flow regulators in that airflow into the facepiece occurs mainly during inhalation. However, there is also a constant flow of air into the mask that keeps it pressurized. So, negative pressure conditions never exist, even during inhalation. Instead, positive pressure conditions exist at all times, and leakage is minimized. This regulator is used most often in hazardous waste operations.

Air Line Respirators

Air line respirators supply air to a facepiece through a length of hose. The hose is connected to either a compressed air cylinder or a compressor that is equipped with equipment to purify the air. The air supply can be used to pressurize the respirator to achieve a high PF. With a pressure demand regulator, a PF of 1,000 can be typically obtained. The air line respirator, shown in Figure 4-9, is being used more and more for lead removal. It does however have the following limitations :

- The air line impairs worker movement, and cannot exceed 300 feet in length according to regulations. Workers must carefully retrace their steps coming off of the job.

- The air line can be damaged. Rough or sharp surfaces can puncture the line. Chemicals on the ground may deteriorate the rubber hose. Falling drums, vehicles and heavy equipment can also damage the air line.

- The location of the system air compressor. The compressor must be located away from potential chemical or contamination hazards. All filters and alarms must be working properly and the system must be maintained according to the manufacturer's recommendations.

Due to the limitations of air line respirators, they are often used with a small bottle of air for escape purposes. The bottle contains a 5 to 10 minute air supply. When this escape bottle is provided, OSHA assigns the unit a PF of 2,000. Escape bottles are required for air line respirators being used in IDLH atmospheres.

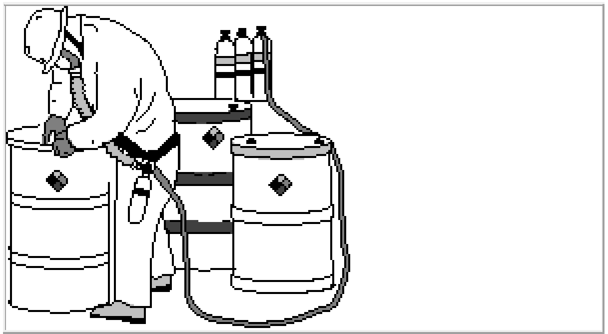


Figure 4-9. Air line respirator.

Self-Contained Breathing Apparatus

A self-contained breathing apparatus (*SCBA*) consists of a facepiece and regulator mechanism connected to a cylinder of compressed air that is worn by a worker (Figure 4-10). SCBAs are commonly used during the most hazardous aspects of waste site jobs because they have a high PF. With an SCBA, a worker doesn't have air line problems. Worker training is essential to the safe use of SCBAs. There are different types of SCBAs with their own set of limitations. They include:

- Closed circuit or rebreathers
- Open circuit SCBAs
    - Entry
    - Escape

Open Circuit vs. Closed Circuit SCBAs

With an open circuit SCBA, exhaled air goes through valves directly into the outside air. The system comprises a tank of breathing quality air containing between 19.5% and 23.5% oxygen, a regulator, and the respirator. Open circuit tanks usually are rated at 30 to 60 minutes.

Figure 4-10. Self-contained breathing apparatus.

Closed circuit SCBAs are called rebreathers because the exhaled air goes back into the system to be recycled. A closed-circuit system consists of a scrubber device to remove exhaled carbon dioxide, a tank of pure oxygen, and a breathing bag to blend the mixture. The closed circuit unit supplies enough breathing air for up to four hours.

Rebreathers work in the following manner. The air for breathing is mixed in a flexible breathing bag. As the wearer inhales and deflates the bag, oxygen flows into the bag from the oxygen tank. The oxygen tank can contain either compressed or liquid oxygen. The exhaled air goes through a filter known as an alkaline scrubber, which removes the carbon dioxide from the exhaled breath. The scrubbed air then mixes with the oxygen in the bag, so that a breathing quality mixture is available for the next inhalation.

One problem for rebreathers is that they typically use demand regulators, which means that they have a lower PF. This demand type rebreather is not recommended for hazardous waste work. There are a few companies that make rebreathers with pressure demand regulators which can be used on a hazardous waste site. NIOSH has given them a PF of 10,000.

Escape vs. Entry SCBAs

The typical pressure demand SCBA is an open circuit unit with a large cylinder. It provides enough air for 30 to 60 minutes and weighs about 25 or 30 pounds. This SCBA is called an entry SCBA and is good for any type of work. Escape SCBAs are small cylinders capable of providing 5 to 10 minutes worth of breathable air. They do not provide enough air for entry to do work, but are only used for emergency evacuation. Some air line respirators have attached escape SCBAs which provide additional protection (PF is 10,000). Other escape SCBAs use hoods and workers wearing non-SCBA respirators use them for emergencies.

Pressure-demand, open-circuit, entry SCBAs are the work-horse respirators used on waste sites when hazards are severe or unknown. They provide excellent protection to the worker. The chief drawbacks to these respirators are their weight and a limited air supply. These limitations greatly affect the work schedule because the work day is broken up into many smaller segments. Also, some workers feel uncomfortable and confined in the respirator. It's important that workers be able to familiarize themselves with SCBA equipment, as well as practice using it before going in a hazardous area.

Protection Factors for Respirators

All respirators differ in the amount of protection they provide since all facepieces leak to a certain degree. The amount of leakage depends on how well the facepiece seals (fits) around the face. If the seal is not good, contaminated air enters, which can lead to adverse health effects.

Industrial Hygenist (IH) use a scoring system called *protection factor (PF)* for ranking the different types of facepieces. Facepieces are tested for leakage by measuring the contaminant levels both outside and inside the facepiece. A ratio of these two measurements provides the PF. Respirator PFs range from 5 to 10,000. The lower the PF, the lower the protection. The higher the PF, the higher the protection. In other words, low PFs provide the lowest protection, and high PFs provide the highest protection.

A PF of 10 means that if the exposure level is 100 $\mu g/m^3$ (micrograms per cubic meter) outside the facepiece, the inside level would be 10 $\mu g/m^3$ due to the facepiece leakage (the ratio of 100/10 = 10). In other words, any respirator with a PF of 10 doesn't eliminate exposure; it cuts the exposure by a factor of 10. Therefore, workers can be exposed above OSHA's permissible exposure limit (PEL), even though they are wearing a respirator. This is not acceptable. IH must take air samples to ensure that the respirator is appropriate for the exposure levels on the job.

Facepieces that have a PF of 10 can only be used in exposures up to 10 times over OSHA's PEL; use in higher levels of exposure cause overexposure.

According to OSHA's Lead in Construction Standard, the contractor may select the respirator that maintains the concentration inside the respirator below 50 µg/m^3 (micrograms per cubic meter) of air.

All facepieces have an acceptable level of concentration use. This level is referred to as maximum use concentration (MUC).

If workers know the PF and OSHA's PEL, they can determine the highest level that a facepiece can be safely used by multiplying the PEL.

MUC = (PF)(PEL)

Note: Workers must not remove their respirator mask while in a contaminated area because even brief exposures can reduce the PF significantly. The PF provided by SCBAs is 10,000. If a worker's mask is taken off 5% of the time (3 minutes out of an hour), it's like reducing the PF from 10,000 down to 100. If a worker's mask is taken off 10% of the time (6 minutes out of an hour), the PF would decrease to 10.

Air Purifying Respirators

The PFs for air purifying respirators follow.

Half-Face Air Purifying Respirators

Half-face air purifying respirators can't be used with lead levels exceeding 500 µg/m^3 (micrograms per cubic meter). When the µg/m^3 exceeds the MUC, workers are exposed above OSHA's PEL.

In the following example, workers can use a half-face respirator because the MUC didn't exceed 500 µg/m^3.

PEL for Lead	**=**	**50 µg/m^3**
PF of Half-Mask	**=**	**10**
MUC = (50)(10)	**=**	**500 µg/m^3**

Reusable half-face air purifying respirators (with HEPA filters) are approved for concentrations up to **500 µg/m^3** (10 times the PEL).

Full-Face Air Purifying Respirators

Full-face air purifying respirators are approved for concentrations up to **2,500 µg/m^3** or 50 times the PEL. This type of respirator provides a higher PF of 50, because it is easier to get a good seal across the forehead, than it is across the nose. (Half-face air purifying respirators seal across the nose.)

Powered Air Respirators

PAPRs with HEPA filters have a PF of 50 (for lead), which permits lead exposures up to **2,500 µg/m³**. OSHA assigns a PF of 25 for loose-fitting hoods or helmets PAPRs (with a flow rate of 6 cfm). Loose-fitting hood or helmet PAPRs with HEPA filters are permitted to be used in lead exposures up to **1,250 µg/m³** (25 times the PEL). Often, OSHA assigns much higher PFs to PAPRs than NIOSH. This is the case with asbestos (OSHA assigns a PF of 100, NIOSH recommends a PF of 50); thus, there are some disagreement between agencies. Because NIOSH is the testing and certification branch of OSHA (they make recommendations to OSHA), and OSHA is a regulatory agency (they make the laws), always follow OSHA's protection factor ratings. These may be found within specific standards for specific hazardous occupations such as lead abatement (29 CFR 1926.62), asbestos abatement (29 CFR 1926.1101), and hazardous waste remediation (29 CFR 1926.65).

Supplied Air Respirators

The PFs for supplied air respirators used for lead exposures follow.

A PF of 1,000 can be, typically, obtained with a regulator known as a "Pressure-Demand." NIOSH recommends a higher rating of 2,000.

There are some supplied airline masks which include an escape SCBA tank. The tank, containing a 5- to 10-minute air supply, is much smaller than the large tank used with the SCBA. When this back-up tank is provided, OSHA assigns the unit a PF of 2,000 (for lead). Only supplied air respirators with back-up tanks can be used in imminent dangerous to life and health (IDLH) atmospheres.

Type CE Continuous Flow Positive Pressure Respirators (Abrasive Blasting Hood or Helmet)

These loose fitting respirators are approved up to **1,250 µg/m³** for lead. This type of respirator has the same MUC as the loose-fitting PAPR because they both provide the wearer air at a constant rate. Therefore, they both have the same limitation of being out breathed (breathing more air than the respirator can provide).

Type CE Positive Pressure, Pressure Demand

A type CE positive pressure, pressure demand respirator may be used for concentrations up to **100,000 µg/m³**. With a compressed-air cylinder back-up, they may be used in concentrations greater than 100,000 µg/m³ or unknown concentrations.

Self-Contained Breathing Apparatus

Because of the limitations in using this type of respirator (30 minute air tank and weight of the unit), this type of respirator is not often used for lead abatement jobs. SCBAs have a high PF (2,000 + for lead) assigned to them and may be used in concentrations of lead greater than 100,000 µg/m³ or unknown concentrations.

Table 4-5 shows the type of respirator required for the airborne concentrations of lead aerosols. (**Notes**: PFs for the powered air purifying respirators are from the most recent data available. Quick referencing materials for Protection Factors, Maximum Use Concentration, and Respirator Profiles are found in Appendix 4-1, 4-2, and 4-3 at the end of this chapter.)

Table 4-5. Respiratory protection for lead aerosols.

Airborne Concentration of Lead or Condition of use	Required Respirator (1)
Not in excess of 500 μg/m³ PF =	–1/2 mask air purifying respirator with high efficiency filters (2) (3). –1/2 mask supplied air respirator operated in demand (negative pressure) mode.
Not in excess of 1,250 μg/m ³ PF =	–Loose fitting hood or helmet powered air purifying respirator with high efficiency filters (3). –Hood or helmet supplied air respirator operated in a continuous-flow mode e.g., type CE abrasive blasting respirators operated in a continuous-flow mode.
Not in excess of 2,500 μg/m ³ PF =	–Full facepiece air purifying respirator with high efficiency filters (3). –Tight fitting powered air purifying respirator with high efficiency filters (3). –Full facepiece supplied air respirator operated in demand mode. –1/2 mask or full facepiece supplied air respirator operated in a continuous-flow mode. –Full facepiece self-contained breathing apparatus (SCBA) operated in demand mode.
Not in excess of 50,000 μg/m ³ PF =	–1/2 mask supplied air respirator operated in pressure demand or other positive-pressure mode.
Not in excess of 100,000 μg/m ³ PF =	–Full facepiece supplied air respirator operated in pressure demand or other positive-pressure mode e.g., type CE abrasive blasting respirators operated in positive-pressure mode.
Greater than 100,000 μg/m ³ or unknown concentration, or fire fighting PF =	–Full facepiece SCBA operated in pressure demand or other positive-pressure mode.

Footnote (1) Respirators specified for higher concentrations can be used at lower concentrations of lead.
Footnote (2) Full facepiece is required if the lead aerosols cause eye or skin irritation at the use concentration
Footnote (3) A high efficiency particulate filter (HEPA) means a filter that is 99.97% efficient against particles of 0.3 micron size or larger.

RESPIRATOR SELECTION CRITERIA

Employers are responsible for selecting the appropriate

respirators for their workers. Many employers use industrial hygienist for this purpose. The industrial hygienist evaluates the information gathered about the site and conditions and applies it to a selection process. The selection process is based upon NIOSH's Respirator Decision Logic and involves answering a series of questions to determine the specific respirator needed.

Therefore, the information gathered is critical in order to use the selection process logic, and must include the following:

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

General Use Conditions/Determination of Contaminants

General use conditions include the following:

- Descriptions of the job tasks to be performed
- Duration and frequency of the tasks to be performed
- Location of the work, the physical demands of the work to be performed
- Comfort of the respirators

Determination of the contaminant's includes the identity of the substances present in the air and the actual measured exposure level of the contaminant on the job. If possible, an estimate of the highest level of exposures that workers are likely to encounter should be included. An industrial hygienist will be necessary to determine the the concentration of chemicals.

Properties of the Contaminants

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

- Form in which the substance is found on the job site (dust, mist, fume, gas or vapor).

- Chemical properties. Such as organic vapor, pesticide, metal, acid gas, etc.

- Toxicological properties of the substance including potential adverse health effects (e.g., carcinogen, warning properties).

Odor Threshold Data

Information on odor threshold is essential to determine whether the contaminant has warning properties at or below the exposure limit that will allow APRs to be selected. If the odor threshold exceeds the exposure limits, the contaminant is not considered to have good warning properties and APRs (except those with end of service life indicators) are not recommended for use. Data on odor thresholds will have to be obtained from industrial hygienist or other experts, such as NIOSH or OSHA.

Exposure Limits

Exposure limits include OSHA's PEL or NIOSH's recommended exposure limit (REL). This information is necessary if maximum use concentration (MUC) are to be calculated for the types or classes of respirators, using their assigned PFs. The *NIOSH Pocket Guide to Chemical Hazards* is an excellent source for this information for many chemicals.

IDLH Concentrations

Contaminant concentrations that are IDLH are life threatening and call for the use of the most protective respirators for the wearer. The NIOSH Pocket Guide to Chemical Hazards provides IDLH concentrations for many chemicals that are found in the workplace. The IDLH concentration for a substance must be compared to the actual concentration measurement of the substance on the job.

Eye Irritation

If a contaminant has the potential to cause eye irritation, a full facepiece, hood, or helmet should be selected instead of a half mask. This is to provide the worker with adequate protection from eye irritation.

Service Life Information

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

RESPIRATOR DECISION LOGIC SEQUENCE

After criteria information is gathered and evaluated, the industrial hygienist follows a sequence of questions to identify the NIOSH recommended class of respirators for the airborne contaminant's. The questions listed below are summarized from the Respirator Decision Logic document. They should be followed in sequence, while using the criteria information that has been gathered to select the proper respirator.

1. Is the respirator to be used for firefighting?
    a. If yes, use a full facepiece SCBA operated in a pressure demand mode.

   b. If no, go to step 2.

2. Will the respirator be used in an oxygen deficient atmosphere?

   a. If yes, any type SCBA or atmosphere supplying respirator with auxiliary SCBA can be used.

   b. If no, go to step 3.

3. Will the respirator be used in emergency situations?

   a. If yes, use a full facepiece SCBA operated in a pressure demand mode or a full facepiece atmosphere supplying respirator operated in pressure demand mode in combination with an auxiliary SCBA operated in pressure demand mode.

   b. If no, go to step 4.

4. Is the contaminant a carcinogen?

   a. If yes, use a full facepiece SCBA operated in pressure demand mode, or a full facepiece atmosphere supplying respirator operated in pressure demand mode in combination with an auxiliary SCBA operated in pressure demand mode.

   b. If no, go to step 5.

5. Is the contaminant exposure level less than the OSHA PEL or NIOSH REL?

   a. If yes, a respirator is not required except for escape. Go to step 7.

   b. If no, go to step 6.

6. Is contaminant exposure level less than IDLH concentration?

   a. If yes, go to step 7.

   b. If no, conditions are IDLH. Use a full facepiece SCBA operated in pressure demand mode or a full facepiece atmosphere supplying respirator operated in pressure demand mode in combination with an auxiliary SCBA operated in pressure demand mode.

7. Is the contaminant an eye irritant?

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

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

8. Determine the minimum PF that is required.

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

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

10. Particulate Respirators

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

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

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

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

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

11. Gas/Vapor Respirators

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

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

b. If no, the respirator will be used for normal work activities. Go to step 11.

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

a. If yes, go to step 11.3.

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

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

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

12. Combination Particulate and Gas/Vapor Respirators

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

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

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

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

c. If yes, go to step 12.3

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

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

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

The respirator decision flow chart shown in Figure 4-11 helps the selector organize the information and keep track of the flow of questions in the sequence.

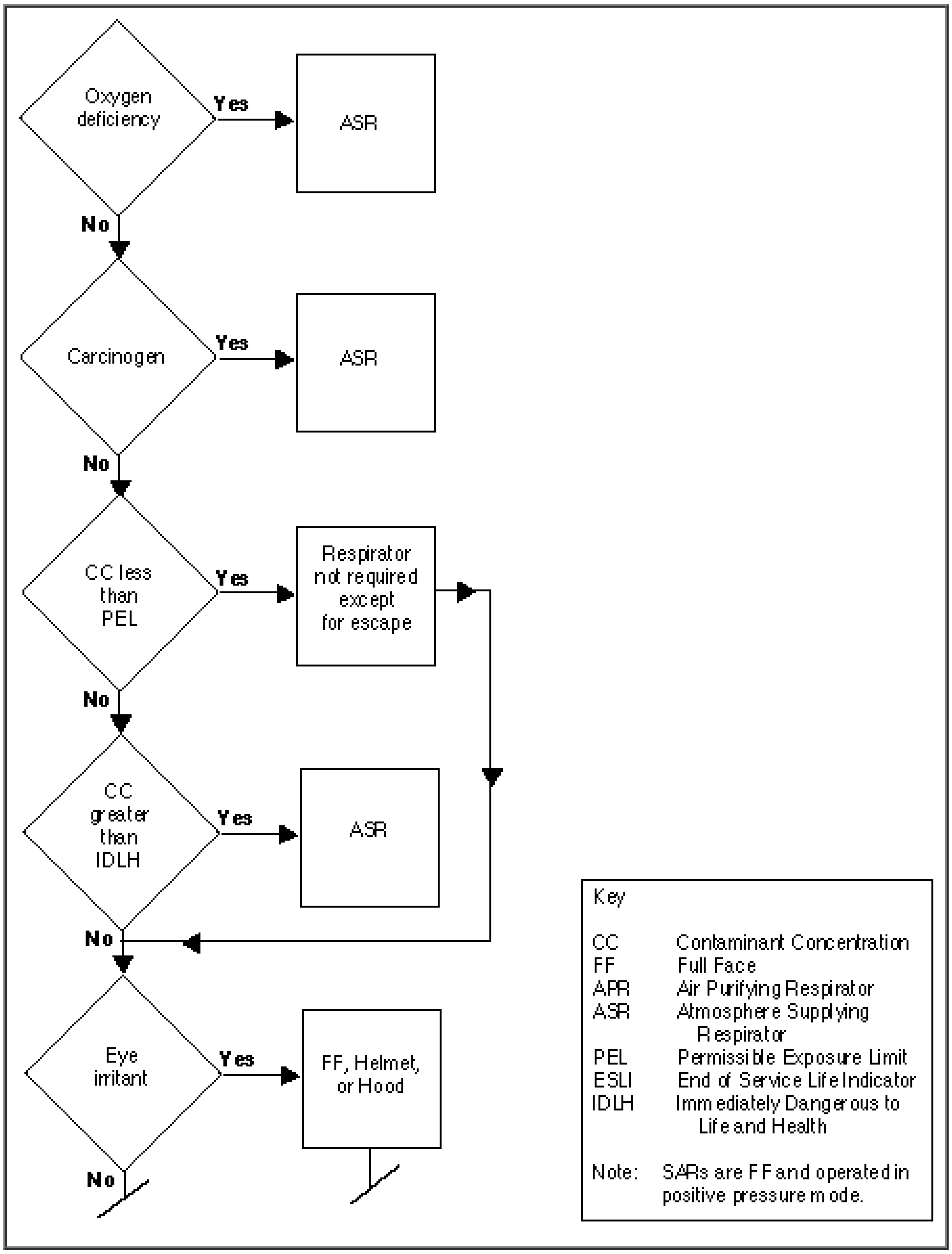


Figure 4-11. Respirator decision flow chart.

RESPIRATOR PROGRAM REQUIREMENTS

The safe use of a respirator is more than just knowing how to put it on. OSHA Standard 1910.134 governs general requirements for respirator usage (Appendix C). The standard requires that employers establish a written respirator program to cover all aspects of respirator use. This program is called the Minimal Accepted Respirator Program (MARP) and includes 11 requirements:

1. Written standard operating procedures (*SOPs*) governing the selection and use of respirators shall be established by the employer.

2. Respirators must be selected for the hazards to which workers are exposed.

3. The wearer shall be instructed and trained in the proper use of respirators and their limitations.

4. The respirators should be assigned to individual workers for their use only.

5. Respirators shall be regularly cleaned and disinfected. Those respirators issued for the exclusive use of one worker should be cleaned after each day's use, or more often if necessary. Those respirators used by more than one worker shall be thoroughly cleaned and disinfected after each use. Respirators used for emergencies, such as SCBAs, shall be thoroughly inspected at least once a month and after each use.

6. Respirators shall be stored in a convenient, clean, and sanitary location.

7. Respirators used routinely shall be inspected during cleaning. Inspection is important because respirators have many parts. Worn, broken or missing parts mean that dangerous exposures can occur. The respirator program must identify the individual who will be responsible for inspection and repair. For respirators like SCBAs, the repair must be done by a qualified person who has been certified by the respirator manufacturer. As with all respirators, SCBA replacement parts cannot be interchanged. They must come from the same manufacturer.

8. Appropriate surveillance of work area conditions and degree of employee exposure or stress shall be maintained.

9. There shall be regular inspections and evaluations to determine the continued effectiveness of the program.

10. Workers should not be assigned to tasks requiring respirators unless it has been determined they are physically able to perform the work and use the equipment. A local physician shall determine what health and physical conditions are pertinent. The respirator user's medical status should be reviewed periodically, (e.g, annually). This requirement is critical. Some workers with health problems can be at risk when wearing a respirator. Examples of health conditions that can be affected by respirator use include asthma, lung disease, or heart disease.

11. Approved or accepted respirators shall be used. The respirator furnished shall provide adequate respiratory protection against the particular hazard for which it is designed in accordance with established standards. NIOSH tests respirators to be sure they meet minimum standards. Only "NIOSH approved" respirators can be used. NIOSH approval is indicated by the NIOSH logo and a TC number. TC stands for *tested and certified*. Substitution of parts or unauthorized repair invalidates the approval.

Air Quality

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

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

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

- Air cylinders must be tested and meet minimum standards to ensure that they can be safely pressurized.
- Air line couplings must be incompatible with outlets for other types of gases. This prevents against accidental injury from use of other gases by mistake.
- Compressors used for air line systems must have built in safety devices. These include:
    - Air purifying filters
    - Alarms for compressor failure
    - Alarms for overheating or high carbon monoxide levels
    - Reserve air systems to provide back up air in the case of compressor failure.
- Compressed oxygen shall not be used in supplied air regulators or in open circuit SCBAs that have previously used compressed air.

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

Use of Respirators

Section 1910.134(e) of the OSHA Standards address usage questions. It includes the requirement that additional standby workers shall be present in areas where the atmosphere is toxic or oxygen deficient and workers might be overcome if their respirators failed. The purpose of the standby worker is to assist co-workers in case of an emergency. It also deals with properly wearing, adjusting, and fitting respirators.

Fit Checks

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

- Positive pressure check
- Negative pressure check

Positive Pressure Check

To perform a positive pressure check, follow these steps:

1. Cover the exhalation valve of the respirator.
2. Exhale gently for about 10 seconds. Don't exhale too hard or push the mask into the face or the check will be inaccurate.

If the respirator fits, a slight pressure should build up inside it. If air leaks out, the respirator does not fit properly and the seal is inadequate. Figure 4-12 illustrates a positive pressure check.

Figure 4-12. Positive pressure fit check.

Negative Pressure Check

To perform a negative pressure check, follow these steps:

1. Cover the filter openings with the palms of hands.
2. Inhale gently and hold a breath for about 10 seconds. Don't push the respirator into the face too hard or the check will be inaccurate.

If the facepiece fits correctly, it should collapse slightly inward. If the facepiece does not fit correctly, it will not collapse and an air leak will be felt. This test is done on SCBAs by covering the hose with the hand and inhaling (Figure 4-13).

Figure 4-13. Negative pressure fit check.

QUALITATIVE FIT TESTING

A *qualitative fit test* (*QLFT*) involves introducing a harmless, odorous, or irritating substance into the breathing zone of the wearer. If the wearer doesn't detect the substance, the respirator fits properly. Three testing agents are used for a QLFT:

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

Qualitative fit testing addresses the following issues:

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

A QLFT is simple and inexpensive, which makes it the most common type of fit testing done for respirators. However, a QLFT relies upon a wearer's subjective response to the testing media. In other words, the wearer must inform the tester if he/she can smell or taste the substance. Because of the subjectivity of the QLFT, a respirator should never be assigned a PF higher than 10 when using this type of test.

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

Fit Testing Protocols

A specific procedure or protocol has been provided by OSHA for the performance of all qualitative fit tests. By following this protocol for each qualitative a fit test, the test results will be consistent from one test to another. A fit test chamber is used to ensure that the concentration of the testing agent is at the same level for the entire fit test. A sample fit test chamber is shown in Figure 4-14.

Figure 4-14. Fit test chamber for isoamyl acetate.

The American National Standards Institute (ANSI Z88.10 Respirator Fit Test Methods) has created protocols for fit testing respirators. OSHA has adopted ANSI's fit testing protocols as their own, and specifies them as the only allowable qualitative fit test protocols permissible for compliance. They may also be referenced through other specific OSHA regulations that require the use of a respirator.

When and Who Should Do the Fit Testing and When

A fit test must be given to any worker who is issued a respirator prior to entering a hazardous atmosphere. A fit test is generally good for 6 months to 1 year. It must be retaken if a worker gains or loses 20 pounds, or has facial or oral surgery. Fit tests must be given by a trained and competent person who has a thorough understanding of respirator use and testing protocols.

Isoamyl Acetate Protocols

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

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

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

Irritant Smoke Test

Another fit testing agent is irritant smoke. It is very irritating to the eyes, nose, and throat, and usually causes the subject to cough. The worker being tested must keep his or her eyes closed during the fit test when wearing a half facepiece. This test requires combination filters for both acid gases and particulates. They are color-coded white and purple or white and magenta.

Saccharin Test

The saccharin test uses a saccharin aerosol. If saccharin leaks into the facepiece, the worker will have a sweet taste on the lips and tongue. Workers must take a taste test before using this testing agent because some people can't taste saccharin. A small nebulizer is used to create a saccharin aerosol inside the test chamber. This test uses HEPA cartridges, which are color-coded magenta.

QUANTITATIVE FIT TESTING

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

OSHA has a procedure for quantitative fit testing. This is the same type of test that is done in research labs to develop the protection factors which were described early in this section.

OSHA REQUIREMENTS

OSHA also requires that workers be trained to perform positive and negative pressure checks and receive fit tests on a regular basis. In addition, OSHA does not permit respirators to be worn when conditions prevent a good seal. These conditions include the following:

- Beard or sideburns
- Skull cap that projects under the facepiece
- Temple pieces on glasses
- The absence of one or both dentures
- Facial scars or deformities which hinder good fit

This is the reason beards are prohibited for workers who must rely on respirators. A beard prevents the mask from sealing against the face, and results in a high rate of leakage.

Eyeglasses are another big fit problem. The temple bars on eyeglasses prevent a respirator from sealing against the side of the head. To go without eyeglasses creates vision-related problems, such as tripping hazards. Respirator manufacturers make fittings which hold the lenses in place in the mask without temple bars. It is an OSHA requirement that this type of fitting be made available to workers with glasses at the employer's expense.

Cooling Garments

Heat stress is a hazard when wearing PPE in warm weather and/or doing vigorous work. There are two different types of cooling devices that have been developed for use in special situations.

- Cool vests - use a jacket or vest with pockets for holding packets of ice or other frozen material.

- Chilled water units - use a small, battery-operated pump to circulate chilled water through tubes which cover the upper part of the body.

USING PERSONAL PROTECTIVE EQUIPMENT

Training is critical to the safe and proper use of PPE for the following reasons:

- Workers become familiar with PPE operation in a safe environment.

- Workers learn their own limitations when wearing PPE.

- A worker becomes more skilled at doing a job while wearing PPE.

- Needless wear and tear on the PPE is reduced.

- Accidental exposures on the job are reduced.

Even though this course provides experience with PPE, site specific training is important. There may be important differences between manufacturers.

Personal Use Factors

Several items can affect the protection provided by PPE. It's important that workers are aware of these items. They include the following:

- Facial hair
- Long hair
- Eyeglasses
- Contact lenses
- Gum and tobacco chewing

Facial Hair

A beard or long sideburns prevent a good seal between the face and the respirator. Studies have shown that any facial hair reduces the protection received from a respirator. This includes a full beard, as well as a few days growth. A mustache is acceptable if it fits under the mask without affecting the seal.

Long Hair

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

Eyeglasses

The temple bars that extend from the ear to the lens prevent the respirator from fitting up against the side of the head. Spectacle kits take care of this situation quite easily. They are inexpensive, and must be provided by the employer. Under no condition should workers hesitate to request a spectacle kit. To work without eyeglasses creates a serious potential for accident and injury.

Contact Lenses

Contact lenses cannot be used with a respirator in a containment for the following reasons:

- A contact lens is porous. It can absorb chemicals causing the chemicals to come in contact with the eye. This can lead to eye injury. It can also lead to drying out of the lens, causing severe eye irritation.

- Sometimes the humidity inside the mask can be very low or very high. The degree of humidity affects the ability to wear contact lens comfortably.

- If a lens were to pop out of the eye in a containment, the worker might be put into a dangerous situation. There would be no way to put the lens back in without taking off the respirator.

Gum and Tobacco Chewing

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

Donning PPE

Donning is the act of putting on PPE. It's not difficult to put on the equipment. However, a specific routine must be followed for the best results.

Before entering the work area (Figure 4-15), personal protective clothing should be donned (put on) in the following sequence

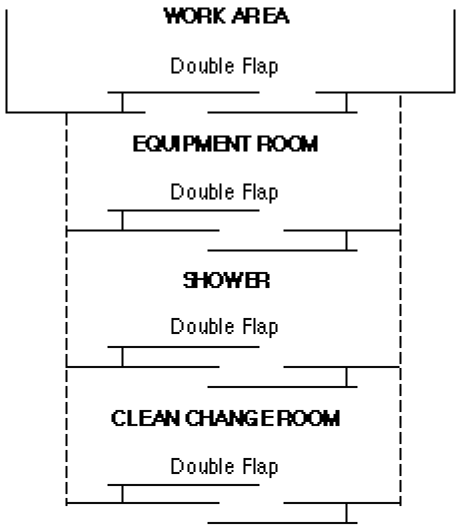


Figure 4-15. Typical decon layout.

While in the clean change room:

1. Remove all street clothes (e.g., undergarments, rings, and watches) and place in a clean location (e.g., bin or locker).
2. Put on the disposable undergarment.
3. Put on the disposable coverall.
4. Put on the disposable foot coverings (if separate foot coverings are used).
5. Tape the ankles to take up slack in the suit and to reduce the chance of tripping. (Tape the pants over foot coverings, if they are two separate items.)
6. Inspect the respiratory equipment for possible problems. Put on the respirator and make sure that it fits and functions properly.

7. Put on the hood or head covering over the respirator head straps.

8. Walk through the airlocks into the Equipment/Dirty Room.

While in the equipment/dirty room:

9. Put on the safety shoes/boots or deck shoes.

10. Put on the gloves. (Cotton or leather gloves can be used during most types of asbestos abatement work. However, when working with caustic paste or chemical strippers, wear rubber-type gloves to prevent any chemicals from being absorbed through the gloves. Also, make sure the gloves are long enough to protect the lower portion of the arm.)

11. Walk through the airlock into the Work Area (Figure 5-15).

While in the work area:

Once inside the work area, workers must never leave without going through the decontamination process (doffing personal protective clothing), unless it's an extreme emergency. Common problems include workers "stepping out" for a cigarette or workers "stepping in" the work area to deliver messages or equipment. These type of actions defeat the purpose of protecting workers and others from lead exposure.

Doffing PPE

Doffing is the act of removing PPE. Again, it is important to follow the specific steps when removing PPE. Doffing is made more complicated by the fact that the PPE may be contaminated.

Before workers leave the work area for any reason, they should doff (take off) their personal protective clothing in the following sequence.

While in the Work Area or Equipment/ Dirty Room:

1. Clean off the excess debris using HEPA vacuums.

2. Remove all the personal protective clothing (except respirators).

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

4. Clean the reusable items as they are removed.

With the respirator still on:

5. Walk through the airlocks to the Shower Room (Figure 4-15).

6. Begin showering, starting at your head and working downward. It is safe to remove your respirator after your head, shoulders and arms have been cleaned. Finish showering as you would normally. Rinse off the respirator prior to moving to the clean room.

While in the clean change room:

7. Clean the respirator. (Change the respirator's filter/cartridge on a regular basis and discard the used one as asbestos-contaminated waste.)

8. Wash face and hands before using the rest room, smoking, drinking, eating, or chewing gum or tobacco. (Small amounts of asbestos on the face or hands can be a major route of exposure. Showers remove any asbestos contamination and are recommended as part of good work practices. Showers should be taken as soon as possible upon leaving the work area.)

9. Put on street clothes.

FALL PROTECTION SYSTEMS

As with any construction site, falls are a hazard on bridge repair or renovation projects. However, wearing PPE can increase the risk of falls or make a fall more dangerous. For example, the added weight of an SCBA can cause a worker to lose balance more easily or make it harder to recover from a trip or stumble. OSHA requires that fall protection systems be used to protect workers when working at heights. These systems include:

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

Guardrail Systems

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

- Toprails and midrails are at least one-quarter inch thick.

- Wire rope used for toprails is flagged at 6-foot intervals with highly visible material.

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

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

Structure

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

Projections

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

Walking/Working Surfaces

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

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

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

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

Personal Fall Arrest

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

- Limit maximum arresting force on a worker to 900 pounds when used with a body belt.
- Limit maximum arresting force on a worker to 1,800 pounds when used with a body harness.
- Be rigged so that a worker cannot free fall more than 6 feet or contact any lower level.
- Bring a worker to a complete stop within 3 1/2 feet.
- Have enough strength to withstand twice the impact energy of a worker falling a distance of 6 feet.

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

Personal fall arrest systems must be inspected prior to each use for wear damage and other deterioration. Defective components must be removed from service.

Self-retracting life lines and lanyards that do not limit free fall distance to 2 feet or less shall be capable of sustaining a load of 3,000 pounds applied to the device in the fully extended position. Ripstitch lanyards that tear apart when a load is place on them shall be capable of sustaining a minimum load of 5,000 pounds. Lanyard ropes, lifeline straps, and body belt and harness components shall be made of synthetic fibers.

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

Positioning Device Systems

These body belt or body harness systems are to be set up so that a worker can free fall no farther than 2 feet. They shall be secured to an anchorage capable of supporting at least twice the potential impact load of an employee's fall or 3,000 pounds, whichever is greater.

Safety Net Systems

Safety net systems must be installed as close as possible under the working surface, but never more than 30 feet below such levels. Defective nets shall not be used. Safety nets shall be inspected at least once a week for wear, damage, and other deterioration. The maximum size of each safety net mesh opening shall not exceed 6 inches x 6 inches. All mesh crossing shall be secured to prevent enlargement of the mesh opening. Each safety net or section shall have a border rope for webbing with a minimum breaking strength of 5,000 pounds.

Connections between safety net panels shall be as strong as integral net components and be spaced no more than 6 inches apart.

Safety nets shall be installed with sufficient clearance underneath to prevent contact with the surface or structure below. They shall be capable of absorbing the impact of a 400 pound drop test. Items that have fallen into safety nets, such as scrap, equipment, and tools, must be removed as soon as possible or at least before the next work shift.

Safety Monitoring Systems

When no other alternative fall protection has been

implemented, the employer shall implement a safety monitoring system. The safety monitoring system is a system in which a competent person is responsible for recognizing and warning workers of fall hazards. This safety monitor shall:

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

Other provisions of the safety monitoring system include the following:

- Mechanical equipment shall not be used or stored in areas where safety monitoring systems are being used.

- Workers shall not be allowed in an area where a worker is being protected by a safety monitoring system, unless they are engaged in roofing work (on low-sloped roofs) or covered by a fall protection plan.

- Workers in a controlled access zone shall be instructed to comply promptly with fall hazard warnings issued by safety monitors.

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

Training

Employers must provide a training program that teaches workers who might be exposed to fall hazards how to recognize such hazards and how to minimize them. In addition, they must issue written certification that identifies the worker as trained with the date of the training. The employer or trainer must sign the certification record. Retraining also must be provided when necessary.

INSPECTIONS

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

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

The responsibility to inspect PPE must be assigned to a specific qualified person. However, it is a good practice for workers to know how to do a basic equipment inspection. Inspection guideline are provided in Appendix 4-2.

ASSIGNMENT SHEET

1. Define the following terms:

   Maximum Use Concentration ______________________________

   Protection Factor ______________________________

   Quantitative Fit Test ______________________________

   Qualitative Fit Test ______________________________

   Tested and Certified ______________________________

2. Define the following acronyms:

   APR ______________________________

   EPA ______________________________

   IDLH ______________________________

   NIOSH ______________________________

   PAPR ______________________________

   PPE ______________________________

   SAR ______________________________

   SCBA ______________________________

   TC ______________________________

3. List the PPE used by lead abatement workers.

   ____

   ____

   ____

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

   ____

   ____

5. List the seven limitations of a half-face APR.

6. List the six limitations of a full-face APR.

7. List the four limitations of the full-face SAR.

8. List the two limitations of SCBAs.

Appendix

RESPIRATOR PROFILES

Half-face Mask

Other Common Names: Cartridge Mask, Type A Mask, Negative Pressure Mask, APR

Assigned Protection Factor: 10

Limitations: Can only be used at low exposure levels, where contaminant's are known and adequate filters are available. Can't be worn in an O_2 deficient atmosphere. Contaminate should have adequate warning properties.

Full-face Mask

Other Common Names: Cartridge Mask, Canister Mask, Negative Pressure Mask APR

Assigned Protection Factor: 50

Limitations: Limited protection. Can only be used when exposure levels are fairly low, (less than 50 x PEL) and contaminant's are known. Limited selection of filters. Can't be worn in an oxygen-deficient atmosphere.

Powered Air-Purifying

Other Common Names: PAPR

Assigned Protection Factor:

50......... OSHA

50......... NIOSH

25......... OSHA (for loose-fitting hood models)

Limitations: Protection depends on charged battery. Use restricted by considerations as other full-face masks. Can't be worn in an oxygen-deficient atmosphere.

Supplied Air Respirator

Other Common Names: Hose Masks, SAR Masks, Type CE Respirators

Assigned Protection Factor:

1,000 - OSHA 1/2-face positive pressure, pressure demand (pppd)

1,000 + - NIOSH Full-face pppd equipped with auxiliary escape tank SCBA operated in pppd mode.

Limitations: Problems with hose (prone to tangling and damage).

Self-Contained Breathing

Other Common Names: SCBA

Apparatus Assigned Protection Factor: 50 for demand units

2,000 for pressure demand units.

Limitations: Very Heavy. Air supply limited 30 or 60 minutes in 2200 or 4500 psi cylinders.

STANDARD OPERATING PROCEDURE 1

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

1. Check general appearance (no deformities).

2. Check harness and strap assemblies.

3. Check nose cup.

4. Check facepiece seal area.

5. Check inhalation valves.

6. Check exhalation valve, valve seats, and cover.

7. Check cartridge or filter holder and gaskets.

8. Check cartridges or filters.

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

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

2. Loosen the harness assembly completely.

3. Hang the facepiece around your neck using the neck strap (if available).

4. Raise the facepiece upward and open, exposing your chin and nose cup.

5. Place your chin in the chin cup and pull the harness over the top of your head. (Make sure there is no hair or other obstructions between your face and facepiece.)

6. Tighten the bottom two harness straps (not too tight).

7. Tighten the top strap slightly.

8. Adjust the mask if needed. The mask should be centered on your face.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

7. Remove the coverings from the exhalation outlet.

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

1. Remove and properly discard filters and/or cartridges.

2. Immerse the respirator in a warm (about 120º) solution of germicidal or disinfecting detergent.

3. Scrub the respirator body and parts gently with a cloth or soft brush.

4. Rinse in clean, warm water (about 120º F).

5. Shake gently to remove excess water. It may be necessary to tip the respirator in several directions.

6. Wipe the respirator with a soft, clean cloth (if available) or allow to air dry away from direct heat or sunlight.

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

8. Replace all damaged or missing parts according to the manufacturer's instructions.

9. Loosen harness straps.

10. Place respirator in a clean bag, box, or storage area in a cool, dry place. Do not place any weight on the respirator.

STANDARD OPERATING PROCEDURE 2

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

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

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

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

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

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

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

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

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

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

- Chin properly placed

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

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

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

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

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

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

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

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

a. Breath normally.

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

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

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

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

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

f. Breath normally.

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

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

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

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

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

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

STANDARD OPERATING PROCEDURE 3

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

1. Smell a weak concentration of the test agent.

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

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

4. Perform a negative pressure check (5 steps from C., Standard Operating Procedure 1).

5. Perform a positive pressure check (5 steps from D., Standard Operating Procedure 1).

6. Wear the respirator for at least 5 minutes.

7. Step into the test chamber or bag.

8. Close your eyes.

9. Breathe normally.

10. Breathe deeply. (Breaths must be deep and regular.)

11. Turn your head from side to side.

12. Nod your head up and down.

13. Read the Rainbow Passage.

14. Jog in place.

15. Breathe normally.

16. If the test agent is detected, get out of the test chamber and readjust the mask. Repeat Steps 4 through 15.

17. If the test agent is still detected, select another size and/or type respirator and repeat Steps 2 through 15.

18. Clean, sanitize, and maintain the respirator (10 steps from E., Standard Operating Procedure 1).

STANDARD OPERATING PROCEDURE 4

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

1. Overall general appearance (no deformities).

2. Harness assembly and connections.

3. Lens and lens gasket.

4. Face to facepiece seal area.

5. Inner nose cup.

6. Inhalation valves and their seating surfaces.

7. Exhalation valves and their seating surfaces.

8. Filter or cartridge assembly.

9. Filter or cartridge.

10. Install proper filter or cartridge.

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

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

2. Loosen the harness assembly completely.

3. Hang the facepiece around your neck using the neck strap (if available).

4. Raise the facepiece upward and open to expose the your chin and nose cup.

5. Place your chin in the chin cup and pull the harness over the top of your head. Make sure there is no hair or other obstructions between your face and facepiece.

6. Tighten the bottom harness straps (not too tight).

7. Tighten the middle two harness straps.

8. Tighten the top strap slightly.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

7. Remove the coverings from the exhalation outlet.

A. Don and doff the following personal protective equipment:

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

Donning:

1. Remove all street clothes, including undergarments. Store street clothes in a clean, convenient location. (Bins or lockers work well.)

2. Put on disposable undergarments.

3. Put on disposable coveralls.

4. Put on disposable foot coverings (if separate disposable foot coverings are used).

5. Tape ankles to take up the slack in the suits and to reduce the chance of tripping. (Tape pants over foot coverings, if separate.)

6. Put on the respiratory equipment. (Respirator equipment should have been inspected and fit checked.)

7. Put on the hood and head covering over the respirator head straps.

8. Pass through airlock and shower into the work area.

9. Put on safety shoes/boots as required.

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

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

Doffing:

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

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

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

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

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

PERFORMANCE TEST FOR INSPECTING AND DONNING AIR PURIFYING RESPIRATORS

Instructions:

Equipment and Supplies Needed:

1. Half-face and full-face respirators (enough for everyone)

2. Variety of canisters and cartridges

3. Copy of the Observation Scale for each laborer

Time: About 10 minutes per laborer.

Directions:

1. Demonstrate, practice, coach, and talk through the task as a training exercise.

2. Divide laborers into pairs to work together.

3. Require each to take the test with the second laborer as observer.

4. Require each laborer to talk through his/her thinking, inspection, and decision-making process while he/she performs the test.

5. Rate each laborer on each task, using Observation Sheet.

6. Discuss score with laborer. Have laborer sign and date form, together with your signature as an instructor.

7. File forms for future reference.

8. Retest, as necessary.

SITE SAFETY

TRAINEE OBJECTIVES

After completing Section 5, you will be able to:

1. Define the following acronyms or terms:

   Accident
   Confined Space
   GFCI
   Hazardous Atmospheres
   LFL
   UFL

2. List the two ways to prevent accidents on the job site.
3. List the five most important actions for eliminating the risk of electrocution.
4. List the five items that should be checked on a regular basis prior to using a ladder.
5. Describe "safe work practices" when working with scaffolding.
6. List four examples of work practices that will help eliminate slips, trips, and falls on the job site.
7. List the three characteristics of a confined space.
8. List the three types of hazardous atmospheres.
9. List the three rules that are always to be followed when working with hazardous atmospheres.
10. The eight basic elements of any comprehensive confined space entry procedure.
11. List nine essential items of a written emergency action plan and fire prevention plan.

SITE SAFETY

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

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

In short, lead abatement workers are subjected to many factors that may reduce their ability to react, and thereby, increase their chances of an accident.

ACCIDENTS

An accident is an undesirable, unplanned event resulting in personal physical harm, damage to property, or interruption of business. An accident may be the result of an unsafe act, such as standing up in a small boat or not wearing a respirator properly. It may also be the result of an unsafe condition, such as a leaking boat or dangerous atmosphere. These situations can be related, since an individual's unsafe act can result in an unsafe condition for someone else.

Preventing Accidents

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

- Eliminate unsafe conditions
- Reduce unsafe acts

Eliminate Unsafe Conditions

Workers must look for conditions that can contribute to an accident, and then work to remove exposure to these conditions. Examples are enclosing live electrical circuits or providing workers with the proper protective equipment. This is the best approach, but it is difficult to eliminate all unsafe conditions. It's more difficult to predict or anticipate where such conditions may exist or develop on an lead abatement job.

Reduce Unsafe Acts

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

GENERAL SAFETY

Safety is "the state of being secure from harm, injury, or danger." To be safe, a worker acts in two ways-offensively and defensively. When a worker acts offensively, he or she protects against controllable actions. When a worker acts defensively, he or she maintains an awareness of actions or situations that may be created by others, or by things taking place.

Regulations established by both Federal and State Occupational Safety and Health Administrations (OSHA) cover many of these hazards. Employers are required to follow these regulations on the job site, including lead abatement job sites. Safety procedures that you are familiar with from your previous work experiences deal with:

- Eye protection
- Hearing protection
- Safety shoes and hard hats
- Scaffolding

- Safety belts
- Ladders
- Grounding electrical equipment
- Hand tools
- Lifting
- Fall Protection

If you continue to follow the procedures that you already are familiar with, they will protect you in situations you may encounter during lead abatement work.

Safe Work Practices

Safe work practices are "those work habits one can adopt and use to protect himself/herself while performing specific duties." Many of the safe work practices used during lead abatement are designed to limit exposure to lead-containing material. The following examples of work practices would apply to most bridge, steel structure, and demolition jobs:

- Using wet removal techniques
- Using negative pressure air filter systems
- Building containments and other barriers
- Cleaning up the work area regularly

General Site Safety

General site safety procedures include the use of engineering controls, safe work practices, and personal protective equipment. Employing all available and possible protective measures provides a safer working environment for all workers.

ELECTRICAL SAFETY

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

Actions to Take

1. Deenergize as much equipment as possible. Use portable floodlight systems for lighting and regularly check the system and wiring for damage.

2. Consider using dry removal in areas immediately adjacent to energized electrical equipment, if de-energizing is not feasible (with prior EPA permission only).

3. Use nonconductive scrappers and vacuum attachments (wood, plastic, rubber).

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

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

6. Make sure all electrical equipment in use has a Ground Fault Circuit Interrupter (GFCI) 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.

7. Use care not to violate insulated coverings with scrappers, scaffolding wheels, etc.

8. Avoid stringing electrical wiring across floors. Elevate wiring, when possible, to keep it away from water on
the floor, and damage from foot traffic and rolling scaffolds.

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

10. Ensure electrical outlets are tightly sealed and taped to avoid water spray.

11. Always perform a prework walk-through to identify potential electrical hazards for abatement workers or equipment that may be damaged by wet removal methods.

12. Use stable wooden or fiberglass ladders, not metal.

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

14. Electrical equipment and lines should be considered energized, unless tested and determined otherwise.

15. Energized parts must be insulated or guarded from worker contact and any other conductive objects.

16. Extension cords used with portable electric tools and appliances must be the three-wire type, and connected to a GFCI.

Extension Cords

1. Should be protected from accidental damage.

2. Should not be fastened with staples, hung from nails, used while still coiled, run underneath poly, or suspended by wire. (Tape is acceptable.)

3. Portable electric hand tools should:

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

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

    - Be double-insulated and labeled as such.

4. 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 deenergized are clearly identified and isolated from all energy sources.
    - Notification received from a designated worker that all switches and disconnects that could supply energy have been deenergized, locked out, and plainly tagged to show people at work.
    - Visual inspections and tests made to assure deenergizing of lines and equipment.
    - Protective grounds applied to disconnected lines or equipment.

5. Separate tag and lockout attached for each crew requiring deenergizing of the same line or equipment.
6. Tags should not be removed from completed work until designated workers report that all crew members are clear, and protective grounds they installed have been removed.

LADDERS AND SCAFFOLDS

Projects involving lead removal on steel structures always present risks to workers from falls, slips, or trips. Scaffolding and ladders are almost always needed to do the job.

Ladders

The following maintenance and use rules should be adhered to:

- Ladders are always maintained in good condition.
- Complete inspections are done periodically.
- No improvised repairs are made.
- Defective ladders are not used.
- Safety feet spreaders and other components of ladders are in good condition. (Missing safety feet create sharp edges that will cut poly floor covers.)
- Movable parts operate freely without binding or undue play.
- Rungs are kept free of grease or oil.
- Use ladders only for their intended purpose. (Ladders should not be used as a platforms or walk boards.)

- Extension type ladders should be used with a 1-4 lean ratio (1 foot out for every 4 feet of elevation).
- Step ladders should only be used when fully open.
- The user faces the ladder while going up and down.
- Tops are not used as steps. If needed, get a longer ladder.
- Bracing on the back legs is not used for climbing.
- Portable ladders are used by one person at a time.
- Ladders are secured to prevent displacement during use.
- All ladders have well designed safety shoes.
- Hook or other type ladders used in structures are positively secured.
- Wood or fiberglass ladders should be selected to avoid electrical hazards of metal ladders.

Scaffolding

Most bridge, structural steel, and demolition projects involve the use of scaffolding. Proper set-up, regular inspection, and basic maintenance is important. In many removal projects, mobile scaffolding provides a convenient and efficient work platform. OSHA standards require that when freestanding 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 tipped over. Since relatively little force is required to tip a scaffold, it becomes important to make sure that wheels on mobile scaffolds turn freely and are lubricated. All components, such as 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 the height. Be careful to keep debris bagged and obstacles off the floor where mobile scaffolds will be used. If a wheel catches on debris on the floor when the unit is moved, additional force will be required to move it. This additional force may tip the unit over. OSHA requires that employers not allow employees to ride on rolling (manually propelled) scaffolding unless the following conditions exist:

- The floor or surface is within 3º of level and free from pits, holes and or obstructions.
- The minimum dimension of the scaffold base when ready for rolling, is at least one-half of the height. Outriggers, if used, shall be installed on both sides of the staging.
- The wheels are equipped with rubber or similar resilient tires.
- All tools and materials are secured or removed from the platform before the mobile scaffold is moved.

Slips, Trips, and Falls

Guard rails and toe boards 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 scaffold without rails or toe boards.

Areas sealed with poly and kept damp to reduce airborne fibers become very slick. Disposable booties are a potential trip hazard. Air and electrical lines create trip hazards. All of these conditions create potential worker hazards, even before removal begins. When lead 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.

Summary

- Consider the height of the work, equipment in use, and any trip hazards. Take a look at "walking surfaces."
- The use of disposable booties may be impractical in many removal situations. They may come apart and create a serious trip hazard. Seamless rubber boots, slip-on shoes, or safety shoes with nonskid soles may be an alternative, depending on the job.
- Inspect ladders and scaffolding for condition. Make sure railings are adequate on scaffolds.
- Minimize water on floors. Wet poly is very slick, and water increases the risk of electrical shock.
- Use care around air lines and electrical cords.
- Suspend electrical lines and cords, when possible, using tape.
- No running or jumping in work areas should ever be allowed.
- Minimize debris on floors.
- Pick up tools, scrappers, etc.

HEAT STRESS

Heat can be a serious hazard on the lead abatement job, especially in crawl spaces and boiler rooms. If workers will be exposed to excessively hot environments, an extensive program specifying safety work practices should be established prior to starting the work. In general, the hotter and more strenuous the job, the greater the chance of heat stress. The severity of heat stress depends on many factors, including:

- Environmental conditions, such as air temperature, air movement and relative humidity, as well as the worker's age.
- Physical fitness.
- Degree of obesity.

- Degree of acclimatization (i.e., workers in winter are less acclimated to heat; and thus, more susceptible).
- Type of clothing worn.

Under normal conditions, the body produces more heat than necessary to maintain the body temperature. Air currents and evaporation of sweat can remove heat when the temperature and humidity of the surrounding air is lower than the body temperature. However, when the air temperature is above body temperature and the humidity is high, the body may not be able to get rid of extra heat fast enough. If the body can't give off heat fast enough, the body temperature will rise.

Workers Who are at Risk

- Workers wearing protective clothing.
- Workers who are suffering from diarrhea or fever.
- Workers who are not physically fit or have not acclimated (become accustom) to the environment.
- Workers with chronic diseases, such as heart disease or diabetes.
- Workers who drink alcohol excessively or use drugs.
- Workers who are obese.
- Workers who regularly take certain medications for depression, nervous conditions, high blood pressure, diabetes, or heart disease.

Forms of Heat Stress

There are four forms of heat stress that result from exposure to high temperature. Generally, productivity also decreases significantly with increased heat.

Heat Rash

Heat rash is the mildest form of heat stress. This is how the body reacts to hot and humid environment. It is caused by heavy sweating where sweat is not easily removed by skin evaporation. Common signs and symptoms include reddening of the skin and development of blisters or a rash.

Heat Cramps

These are probably due to a low sodium chloride level in the blood. The worker experiences severe, painful muscular contractions of the arms, legs, hands, and trunk. Cramps are always preceded by marked sweating. Body temperature may be above or below normal with a rapid pulse. Cramps are usually in the extremities, and generally, follow heavy exertion, but may also take place hours later. If heat cramps occur, the worker should rest in a cool place, and increase fluid intake. (See "Preventive Measures.")

Heat Exhaustion

This is the result of not getting enough water. The individual becomes pale, has cold, clammy skin, and is weak to the point of exhaustion. He/she may also have a headache, vomiting, nausea, muscle cramps, diarrhea, and giddiness. The blood pressure is low, and the temperature may be above or below normal. The condition resembles surgical shock. It may be preceded or followed by heat cramps. There is no increase in body core temperature. If heat exhaustion occurs, the worker should rest in a cool area and drink plenty of water (i.e., 1 pint). (Refer to the topic heading, "Preventive Measures" in this section.)

Heat Stroke

Heat stroke is the most serious heat disorder and results from exposure to excessive heat. The skin becomes hot and dry (or red and mottled), and there is a rapidly rising body temperature with a rapid pulse and deep breathing. Blood pressure is high, and there may be unconsciousness, convulsions, or deep coma. The onset may be gradual, with mental excitement and dryness of mouth and skin, or may be sudden with delirium, stupor, or coma. This condition has a death rate of 30% to 50%. If a worker experiences the symptoms of heat stroke, he or she should seek medical attention immediately.

Table 5-1 summarizes the four forms of heat stress and their signs and symptoms.

Table 5-1. Signs and symptoms of heat stress.
The four categories of heat stress:
Heat Rash Caused by heavy sweating, where sweat is not easily evaporated. Signs and symptoms include: • Skin reddening • Blisters or a rash
Heat Cramps Caused by heavy sweating with inadequate electrolyte replacement. Signs and symptoms include: • Muscle spasms • Pain in the hands, arms, feet, legs, and abdomen.
Heat Exhaustion **Caused by increased stress on various body organs, and the blood circulation system.**

Signs and symptoms include: • Pale, cool, moist skin • Heavy sweating • Dizziness • Nausea • Fainting • Rapid, shallow breathing
Heat Stroke This the most serious form of heat stress. Temperature regulation fails and the body temperature rises to critical levels. Immediate action must be taken to cool the body before serious injury or death occurs. Competent medical help must be obtained. Signs and symptoms are: • Dizziness and confusion • Nausea • Strong, rapid pulse • Coma • Red, hot, usually dry skin • Lack of or reduced perspiration

Preventive Measures

Avoid entering hot areas whenever possible.

- Try to enclose or ventilate equipment or processes generating heat or steam. For example, reflective shielding placed between workers and the source of radiant heat (i.e., furnace) can reduce workers' exposure to heat.

- Use exhaust ventilation to draw heat from the area. Have high efficiency particulate air (*HEPA*) exhaust in hottest areas. Supply area with colder air. Fans are not recommended when loose lead material is present because fibers will become airborne.

- Implement short work periods and long rest periods (in a cool area). It may be necessary to have up to 75% rest time depending on work conditions.

- Drink plenty of water to replace lost fluids even if you are not thirsty. Some studies have shown that drinking commercial thirst quenching, (electrolytic solution) is helpful. Workers with heart conditions or on low salt diets should consult with a physician first. Avoid alcohol consumption because it can lead to further dehydration.

- Slowly acclimatize workers to the hot environment. Acclimatization is the process by which humans are able to adjust to hot environments by means of physiological and psychological adjustments. Gradual exposure to a hot environment works best. Acclimatization can be quickly lost. New employees or workers returning after a weekend or vacation will be less able to tolerate heat than those working regularly in a hot environment, and will then be more susceptible to heat stress.

Monitoring for Heat Stress

- Check heart rate during rest breaks. If it is greater than 120, work time should be reduced and rest time increased.

- Check temperature at the end of the work period, but before drinking fluids. If it is greater than 99.6ºF (37.6ºC), work time needs to be reduced and rest time increased. If it is greater than 100.6ºF (38.1ºC), remove protective work clothing.

- Check weight (in the nude) before and at the end of work. If the loss of weight is greater than 1.5% of total weight, take in more fluids during work. As an example, if normal weight is 200 pounds and more than 3 pounds (.015 x 200 lbs = 3 lbs) is lost from the start to the end of the shift, it is necessary to drink more fluids .

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

Treatment/Emergency Measures

- Get medical help immediately. Emergency telephone numbers should be posted at the work site.

- Move victim to cool area. Remove worker's respirator if he/she is wearing one.

- Soak clothes thoroughly with water (or remove clothes), and fan person vigorously to increase cooling.

CONFINED SPACE ENTRY

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

- Adequate size and shape to allow a person to enter.
- Limited openings for entry and exit
- Is not designed for continuous human occupancy

Improper entry into confined spaces results in a significant number of industrial and construction accidents, including fatalities, every year.

Typical examples of confined spaces include storage tanks, tank trucks, process vessels, boilers, pipelines, pits, septic tanks, vats, manholes, utility vaults, ventilation ducts, silos, sewers, and trenches.

Confined Spaces Hazards

The primary hazards that may be found in confined spaces are:

- Hazardous atmospheres
- Moving or driven equipment
- Process liquids and steam or water

Hazardous Atmospheres

Since, in most confined spaces there is a lack of natural air movement, the most common hazard is hazardous atmospheres. There are three types of hazardous atmospheres that workers should recognize:

- Oxygen-deficient atmospheres
- Flammable atmospheres
- Toxic atmospheres

Oxygen-deficient Atmospheres

An oxygen-deficient atmosphere has less than 19.5% available oxygen. Any atmosphere with less than 19.5% oxygen should not be entered without an approved self-contained breathing apparatus (SCBA) or airline respirator with escape. Even if testing shows oxygen levels above 19.5%, remember there is normally a lack of ventilation or natural air movement in a confined space. Any work that uses up oxygen, such as welding, cutting, or brazing, may cause the oxygen level of the confined space to fall below 19.5%. It is important, therefore, to periodically test the air in the confined space for oxygen content when work is being performed without an appropriate SCBA, airline respirator, or ventilation.

Flammable Atmospheres

A flammable atmosphere develops when a flammable gas, vapor, or dust is present in the air at concentrations between the Lower Flammable Limit (LFL) and the Upper Flammable Limit (UFL). If a source of ignition (e.g., a sparking electrical tool) is introduced into a confined space containing a flammable atmosphere, an explosion will result.

Toxic Atmosphere

Most substances (liquids, vapors, gases, mists, solid materials, and dusts) should be considered hazardous in a confined space. The following are some sources of toxic substances that may be present in confined spaces:

- Liquids, residues, or sludges from material previously stored.

- Toxic materials that have been absorbed into the walls and will give off toxic gases or vapors.

- Hazardous gases produced by decomposition.

- Hazardous gases that have accumulated at the bottom of the confined space because they are heavier than air.

- Materials produced by, or used in, the work being performed in the confined space. For example, cleaning solvents, paints, and welding fumes.

In view of these extremely hazardous atmospheres that can exist in confined spaces, the following rules should always be followed:

- Never enter a confined space if it contains flammable vapors or gases greater than 10% of the lower explosive level (LEL) or lower flammable level (LFL), or if the concentration of a toxic material is immediately dangerous to life and health (IDLH).
- Always wear an approved SCBA when entering an atmosphere with less than 19.5% oxygen.
- When concentrations of toxic materials are above 50% of the permissible exposure limit (PEL), but below the IDLH, workers may enter if they are wearing the appropriate personal protective equipment (PPE).

Reducing the Danger

The following procedures will reduce the dangers associated with confined spaces:

- Isolation
- Testing the atmosphere
- Ventilation
- Standby and rescue

Isolation

Isolation of a confined space eliminates the hazards associated from moving or driven equipment, and the unexpected entry of process liquids, steam, or water.

Isolation is the process whereby the space is removed from service by:

- Locking out electrical sources, preferably by disconnecting the switches from the equipment.
- Blanking and bleeding lines which contain process fluids, steam, and water; or pneumatic and hydraulic lines.
- Disconnecting or locking out drives on mechanically driven equipment.
- Securing moving parts (within the confined space) with latches, chains, locks, or other devices.

Testing the Atmosphere

It is important to understand that some gases or vapors are heavier than air and will settle to the bottom of a confined space. Also, some gases are lighter than air and will be found around the top of the confined space. Therefore, it is necessary to test all areas (i.e., top, middle, bottom) of a confined space with properly calibrated testing instruments to determine what gases are present. If testing reveals oxygen deficiency, or the presence of toxic gases or vapors, the space must be ventilated and retested before workers enter. If ventilation is not possible and entry is necessary (e.g., for emergency rescue), workers must have appropriate respiratory protection.

Ventilation

Ventilation by a blower or fan may be necessary to remove harmful gases and vapors from a confined space. There are several methods for ventilating a confined space. The method and equipment chosen are dependent upon the size of the confined space openings, the hazards gases to be exhausted, and the source of makeup air.

Under conditions where flammable gases or vapors have displaced the oxygen, but are too rich to burn, forced air ventilation may dilute them until they are within the explosive range. Also, if inert gases (e.g. carbon dioxide, nitrogen, argon) are used in the confined space, they may have displaced the oxygen content. Therefore, the space should be well ventilated and retested before a worker may enter.

A common method of ventilation requires a large hose with one end attached to a blower and the other lowered into the confined space. For example, a manhole would have the ventilating hose run to the bottom to blow out all harmful gases and vapors. The air intake would be placed in an area that will only draw in fresh air. Ventilation should be continuous, where possible, because in many confined spaces, the hazardous atmosphere will form again when the flow of air stops.

Standby and Rescue

A standby person should remain on the outside of the confined space and be in constant contact (visual or speech) with the workers inside. The standby person should not have duties other than to serve as standby and know whom to notify in case of emergency. Standby personnel should not enter a confined space until help arrives, and then only with proper equipment.

More than 50% of the workers who die in confined spaces are attempting to rescue other workers. Rescuers must be trained in, and follow, established emergency procedures and use appropriate equipment and techniques (e.g., lifelines, respiratory protection, standby persons). Steps for safe rescue should be included in all confined space entry procedures. Rescue should be well planned and drills frequently conducted on emergency procedures. Unplanned rescue, such as when someone instinctively rushes in to help a downed co-worker, can easily result in multiple fatalities.

Confined Space Entry Procedure

Basic elements of any comprehensive confined space entry procedure include:

Authorization and Permit

No person should enter a confined space, unless a confined entry permit has been prepared and authorized by the appropriate individual (normally, a supervisor).

Pre-entry Precautions

Ensure that the confined space has been isolated to prevent entry of hazardous materials. Locking and tagging, removal of spool pieces, and installation of blanks are acceptable methods. Lock out and tag out all associated electrical and mechanical equipment.

Pre-entry Testing

Confined spaces shall be tested for hazardous atmospheres, including, as a minimum, flammable vapors (percentage of LEL), oxygen deficiency (percentage of oxygen) and toxic materials (concentration of any unknown contaminant). Result of testing (instrument readings) should be noted on entry permit.

Entry Decision

No one may enter a confined space until all items on the confined space entry permit are completed and signed. Appropriate authorization signatures must be in place.

Standby Observer

Personnel working in a confined space must be under the constant observation of a standby observer who is outside the confined space. The standby person should review the checklist before permitting any confined space entry.

Rescue Harness

Every person entering a confined space must wear a rescue harness or wristlets with a lifeline attached. The end of the lifeline must be secured outside the confined space.

Dangerous Atmosphere

Where an oxygen deficiency or a potential fire hazard exists, or could develop, all persons within the confined space must wear SCBA.

Emergency Actions

In the event of an emergency, the standby person must:

- Never enter the confined space
- Promptly sound alarm or communicate the emergency to emergency personnel
- Leave post only to report emergency or for self-protection

FIRE SAFETY

A few fire safety concerns are exits, travel distances, emergency lighting, and alarm systems.

Some protective clothing will burn and melt quickly. It can shrink, adhere to skin, and rip as it burns. Heavy black smoke is a combustion byproduct. Polyethylene and other fabric type containments are combustible. They start burning slowly and pick up speed as more heat is generated, giving off heavy smoke as the fire progresses. Flame spread is slow and steady. Sheeting should be kept away from heat sources, such as transformers, steam pipes, and boilers that will be heated during removal. (Polyethylene should not be allowed to come in contact with surfaces above 150ºF.)

Avoiding Fire Problems in Control Areas:

- In case of fire, the fire hazard becomes more immediate than the lead hazard, and workers may need to break the barriers. This should be communicated to workers in the emergency action plan for the job site.

- Ensure all sources of ignition are removed. Be sure that gas and other fuel sources are cut off and that pilot lights in boilers, heaters, hot water tanks, and compressors are extinguished.

- Locate "hot spots." Often equipment will have to be draped instead of sealed off to prevent overheating (e.g. computers, terminal boards, switch panels, transformers).

- Cut off supply to steam lines, electric and steam heaters, and radiators. Do not permit the poly to come in contact with hot surfaces.

- Do not allow lighters or matches into the work area.

- Strictly enforce no smoking, eating, or drinking rules inside the work area.

- When using an oxygen/acetylene torch for cutting, post a fire watch along with the appropriate fire extinguisher. Do not use CO_2 extinguishers in confined or enclosed spaces. Dry chemical extinguishers are effective, but the powder is a respiratory irritant.

- 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.

- Reduce the amount of flammable and combustible materials inside a space to a minimum prior to hanging plastic. This includes removal of any chemicals, flammable liquids and heat sensitive materials.

- Mark exits from the work area. Post directional arrows when exits are not visible from remote work areas. This can easily be done using duct tape on the polyethylene walls and barriers.

- Keep trash and debris to a minimum (e.g., tape, poly, bags, lumber).

- 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 ensure secondary exits are not blocked.

- Lighting should be provided in exits and exit routes .

- Be alert for flammable vapors in industrial areas (solvents, such as naphtha, toluene, and xylol). This is especially critical in industrial vacuuming operations, where vacuum motors are not explosion proof. Compressed air vacuums may be required.

- A telephone should be available at all times for notifying authorities in an emergency.

- Post local fire department and rescue squad phone numbers. Advise them of the operations in progress.

- Make sure there is a monitor outside at all times, trained in emergency procedures. Someone should be trained in first aid and in the treatment of heat stress.

Effective December 11, 1980, OSHA revised its fire safety standards. OSHA now requires a written emergency action plan and fire prevention plan. Briefly, the essential elements of the plans include:

- The manner in which emergencies are announced.

- Emergency escape procedures and emergency escape routes.

- Procedures for workers who must remain to operate critical plant operations that may take time to shut down.
- Procedures for accounting for all workers after evacuation.
- Rescue and medical duties.
- Names and/or job titles of individuals to contact for additional information.
- A list of the major workplace fire hazards.
- Names and/or job titles of individuals to contact for maintenance of fire prevention equipment.
- Names and/or job titles of individuals responsible for the control of fuel source hazards.

ASSIGNMENT SHEET

1. Define the following acronyms or terms:

   Accident

   ____

   ____

   Confined
   Space ____

   ____

   GFCI____

   ____

   Hazardous
   Atmospheres ____

   ____

   LFL ____

   ____

   UFL ____

   ____

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

   ____

   ____

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

   ____

   ____

   ____

   ____

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

5. Describe "safe work practices" when working with scaffolding.

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

7. List the three characteristics of a confined space.

8. List the three types of hazardous atmospheres.

9. List the three rules that are always to be followed when working with hazardous atmospheres.

10. The eight basic elements of any comprehensive confined space entry procedure.

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