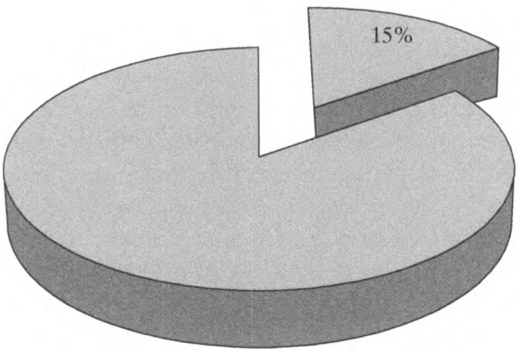
CHAPTER 12

Personal Protection and First Aid



Percentage of OSHA General Industry citations addressing this subject

In a way, it is unfortunate that this chapter is even necessary. The need for personal protection implies that hazards have not been eliminated or controlled. And the need for first aid implies something even worse! When feasible, engineering control of the hazard is preferred over the use of personal protective equipment (PPE). As discussed in Chapter 1, we realize that some risks will always remain; our goal is to eliminate *unreasonable* risks, not all risks. The job of improving safety and health in the workplace will never be completely finished; so we must concern ourselves with the need to provide personal protection against hazards that have not been completely eliminated and to provide first aid when an accident does occur.

The problem of providing personal protective equipment seems straightforward and easy enough to understand. However, the simplicity of the problem is an illusion, and many industrial safety and health managers fall into its trap. For instance, it would seem that if the noise level in the production area is too high, the solution to the problem would be to provide ear protection for the workers. However, anyone who has actually confronted this problem knows that the solution is not that simple. For a variety of reasons, many people do not want to wear ear protection. They may be shy about the appearance of ear protection equipment, they may feel discomfort or perhaps even pain, they may feel it interferes with their necessary hearing or efficiency, or they may feel that use of personal protective equipment is their own business, not their employer's. The bases for these complaints and what to do about them will be taken up later in this chapter, but first we will discuss the hazards for which personal protection may be needed and the types of equipment available to meet these needs.

The matter of personal protective equipment becomes very delicate when employees bring their own equipment to work. If the equipment is not properly maintained, who is responsible—employer or employee? OSHA's position is that the employer is responsible. As safety and health manager, consider the following logic: If employees bring their own personal protective equipment to work, is it not possible that the equipment itself could represent a hazard? Personal protective equipment must be properly selected to match the hazard, and employees bringing their own equipment might falsely think they are safe when their equipment could actually be malfunctioning or inappropriate.

Even if the employee works in a job that does not require personal protective equipment, the use of faulty or inadequate equipment might tempt the worker to take chances. For instance, suppose that a maintenance worker who has no need to even approach the edge of a rooftop while maintaining air-conditioning equipment wears his or her own rope attached to a leather belt as added protection, not required by company policy. Then suppose that some unusual situation tempts the employee to approach the edge of the building and the false sense of security from the improvised "safety belt and lanyard" causes the worker to proceed without caution. An accidental fall could cost the worker's life when the leather belt breaks under a 2000-pound shock load due to the fall. Alternatively, even if the leather belt withstands the shock load, the worker could be killed by the shock itself if the lanyard is too long and is nonelastic. These are facts workers might not know, and when they improvise or bring their own personal protective equipment to work, the employer should ensure that the equipment is adequate for the situation and is properly maintained.

PROTECTION NEED ASSESSMENT

The first federal standards for personal protective equipment emphasized the design and performance of the equipment itself, not when such equipment should be used. The reason was that there were really no detailed consensus standards that addressed when personal protective equipment was required. A notable exception was hearing protection, which was required when neither engineering nor administrative controls were capable of reducing noise exposure to acceptable levels.

In the mid-1990s, OSHA addressed this problem by promulgating a more specific standard for personal protective equipment that mandated a more comprehensive program of the use of personal protective equipment in general. A key element in this new standard was the requirement for the employer to conduct a hazard assessment to determine whether personal protective equipment is needed for various jobs found within the plant. It is recognized that such an assessment is a judgment call, so the safety and health manager should not expect to find a standard that specifies exactly when various personal protective equipment must be used. However, there are guidelines that can be used to assist in making a decision. The nonmandatory appendices to the standards are often helpful in providing such guidance. The sections that follow will reflect the suggestions made by standard appendices and should be considered a resource for the personal protective equipment needs assessment and selection of appropriate equipment. Besides the type of equipment selected, the fit of such equipment to the particular employee who will wear it is also important. For respirators, fit is *critical* to the protection that the respirator will provide. This topic will be covered in more detail later in this chapter.

Some persons have questioned who should be required to pay for personal equipment, employer or employee. Most, but not all, employers have assumed this responsibility from the beginning of OSHA enforcement of the general provision that such equipment be "provided, used, and maintained." Note that the wording is not explicit regarding who is to pay for such equipment. In late 2007, OSHA ruled that the employer was responsible for providing all necessary PPE free of charge to its employees (Employer Payment for Personal Protective Equipment, 2007). This was to reduce misuse or nonuse of PPE by increasing availability of PPE meeting all applicable standards. In this ruling, OSHA made several exemptions. These exemptions are certain safety shoes, prescription safety eyewear, and logging boots. It was determined that these items could be used by employees outside of work. The key to determining exemption is whether the work renders such items unusable offsite or if such items are not designed for special use on the job.

PERSONAL PROTECTIVE EQUIPMENT (PPE) TRAINING

Another important provision of the general personal protective equipment standard is the requirement for employee training in the proper use of the equipment. The basic premise of enforcement authorities is that if personal protective equipment (PPE) is needed, then the employees must be trained to use it properly. Employees need to know when PPE is necessary, what kinds of PPE are required, and how to wear it effectively. To avoid developing a false sense of security, the employee needs to know the limitations of the PPE he or she is using, including its useful life under proper care and maintenance. Even if the employee has received PPE training, workplaces often change, rendering the previous PPE obsolete for the task. If either the workplace changes or the PPE changes, the employer must take a responsible position and retrain the employee if necessary. Both the initial training and the retraining must be documented with a certificate that identifies the names of employees trained, the dates, and the subject for which the employee is certified.

Thus far, this chapter has covered general requirements for personal protective equipment, the assessment of the need for such equipment, and the required employee training for the use of such equipment. We now turn to the specific types of personal protective equipment for various hazards, starting with hearing protection.

HEARING PROTECTION

As might be expected, the greatest emphasis in providing personal protective equipment coincides with the principal problem in environmental control, covered in Chapter 10—the problem of noise. If engineering or administrative control measures are unsuccessful in eliminating the hazard of noise in the workplace, management must turn to personal protective equipment to shield the worker from exposure.

The most important factor in selecting a type of noise protection is probably effectiveness in reducing the decibel level of noise exposure. However, this is by no means the only important factor, and selection can be somewhat complicated. Economics is always a factor, and if limited effectiveness is all that is necessary in a given situation, cheaper devices can be selected. Employee comfort is probably at least as important a factor as economics. The worker comfort factor goes beyond the simple goal of promoting worker satisfaction; it affects the amount of protection the worker will receive. If workers find a type of ear protection uncomfortable or awkward to wear, they will use every excuse not to wear it, which results in loss of protection. The next paragraphs consider the merits of various types of ear protection.

Cotton Balls

Ordinary cotton balls, without addition of a sealing material, are virtually worthless as a means of personal protection from noise.

Swedish Wool

Similar in feel to cotton, Swedish wool is a mineral fiber that has much better attenuation values than cotton. Swedish wool is somewhat effective as is, but is much more effective when impregnated with wax to make a better seal. One problem with Swedish wool is that it can tear when it is pulled out. To alleviate this problem, Swedish wool sometimes comes in a small plastic wrapper that is inserted with the wool. Swedish wool can be considered only fairly reusable; reuse will depend on personal hygiene, quantity of earwax, and worker preference.

Earplugs

The most popular type of personal protection for hearing is the inexpensive rubber, plastic, or foam earplug. Earplugs are practical from the standpoint of being easily cleaned and reusable. Workers often prefer earplugs because they are not as visible as muffs or other devices worn external to the ear. However, within this advantage lies a pitfall: Workers may be more complacent about using the earplugs when it is not immediately obvious to the supervisor whether the earplugs are being worn. The noise attenuation for properly fitted earplugs is fairly good, falling somewhere between that of Swedish wool and the more effective earmuffs.

Molded Ear Caps

Some ear protectors form the seal on the external portion of the ear by means of a mold to conform to the external ear and a small plug. Since human ear shapes vary so widely, fit is a problem. Molded ear caps are more visible than earplugs, which has both advantages and disadvantages, as discussed earlier. Molded ear caps may be more comfortable to the wearer, but are more expensive than earplugs.

Earmuffs

Earmuffs are larger, generally more expensive, and more conspicuous than Swedish wool, plugs, or caps, but they can have considerably better attenuation properties. The attenuation capability depends on design, and more variety in design is possible with earmuffs. Although some workers object to wearing conspicuous earmuffs, some workers prefer them, stating that they are more comfortable than earplugs.

Helmets

The most severe noise-exposure problems may force the safety and health manager to consider helmets for personal protection against noise. Helmets are capable not only of sealing the ear from noise, but also of shielding the skull bone structure from sound vibrations that can be transmitted to the ear as noise. Helmets are the most expensive form of hearing protection, but have the potential of offering protection from a combination of hazards. Properly designed, the helmet can act as a hard hat and a hearing protector at the same time.

It must be remembered that fit is very important for all types of hearing protectors. As in noise enclosures or sound barriers, the material itself might have excellent sound-attenuation properties, but if there is a leak or crack, most of the effectiveness of the device is lost.

DETERMINING THE NOISE REDUCTION RATING

An essential part of the use of hearing protection is to understand the amount of protection provided by the hearing protection. In the previous sections, many different forms of hearing protection were listed. The extent to which these reduce the amount of noise the ears are exposed to is known as the Noise Reduction Rating (NRR). When worn properly, hearing protection can provide up to the amount of protection from the listed NRR. However, there are operational factors which can impact this protection. When assessing effectiveness of the hearing protection, a dosimeter can be used. If it is a C-weighted dosimeter, then the full NRR can be used to determine the reduction in noise provided by the hearing protection. If an A-weighted dosimeter is used, then the NRR must be reduced by 7 dB prior to determining the reduction. For example, if one has earplugs which provide an NRR of 25 dB and measures exposure using a C-weighted dosimeter, then one can be exposed to 85 dB + 25 dB = 110 dB of noise and stay at the PEL. If only an A-weighted dosimeter is available, then that number becomes 85 dB + (25 dB − 7 dB) = 103 dB. In many instances such as airports, additional protection is needed. In these instances, dual hearing protection may be used. However, the use of a second set of hearing protection (e.g., earplugs ~25 dB and earmuffs ~30 dB) does not provide a 55 dB protection. It only provides 5 dB more than the largest NRR protection, in this case 30 dB + 5 dB = 35 dB (29 CFR 1910.95 App B).

EYE AND FACE PROTECTION

The use of safety glasses has become so widespread and so many different styles are now available that many safety and health managers establish a rule that the safety glasses must be worn throughout the plant. A general custom in industry is to require visitors to wear safety glasses during plant tours.

There is a difference between *street* safety glasses and *industrial* safety glasses. Visitors or employees who claim that their prescription glasses are "safety glasses" probably mean that they have street safety lenses. Industrial safety lenses must pass much more severe tests to meet ANSI standards. This is not to say that street safety lenses are not adequate for some industrial environments. Eye protection standards are not specific about which jobs do and which do not require safety lenses—street or industrial. It is good to have exacting standards to be sure that safety glasses will meet uniform performance standards. However, responsibility for deciding when eye protection equipment is necessary usually falls on the safety and health manager—not the optics industry, not the standards, and not enforcement agencies.

The OSHA eye protection standard recognizes the concept of "clip-on side shields" provided that the side shields meet pertinent requirements of the OSHA standard for eye protection. One of these requirements is that the side shields be tested *on the frames* by the manufacturer. Thus, the safety and health manager is cautioned to beware of clip-ons that have not been tested by the manufacturer. The safety and health manager should also be careful regarding protective lenses that fit *over* prescription lenses. The protective lenses must not move or disturb the function of the prescription lenses.

A word of caution is in order for the safety and health manager who is setting forth a policy on the wearing of safety glasses. It can be as bad a mistake to require safety glasses in those areas of the plant where there is no eye hazard as it is to not require safety glasses in areas where they are needed. The peril is that workers will not respect the safety glasses policy, and use of the glasses will not be uniform. Eye injuries can be the result—in addition to violations of code. It is easy for inspectors to establish violations when they observe workers not wearing eye protection in the presence of an established company rule requiring eye protection. However, some safety and health managers say that a simple plantwide rule is easiest to enforce. The costs on both sides of the question are great, and the decision to require eye protection must be made with care.

There are some jobs for which industry and enforcement agencies alike have seemed to come to a consensus on the need for eye protection. Machining operations that produce chips or sparks are almost universally conceded to necessitate the use of eye protection. Notable among these operations are those of grinding machines, drill presses, and lathes. Both metal and wood materials can produce dangerous eye hazards when machined. Corrosive liquids or other dangerous chemicals also represent eye hazards when poured, brushed, or otherwise handled in the open. When working with such materials, face protection may be needed in addition to eye protection. Guidelines for the specification of various types of eye protection for typical hazards are offered in Table 12.1.

One question the safety and health manager is likely to be asked is whether contact lenses are considered safe in the workplace. First, it must be emphasized that contact lenses are no substitute for adequate eye protection, such as safety glasses, goggles,

TABLE 12.1 Appropriate PPE for Various Hazards

Source	Assessment of hazard	Protection	
IMPACT—Chipping, grinding machining, masonry work, woodworking, sawing, drilling, chiseling, powered fastening, riveting, and sanding	Flying fragments, objects, large chips, particles, sand, dirt, etc.	Safety glasses with side shields or face shields, depending upon the hazard and its severity	
HEAT—Furnace operations, pouring, casting, hot dipping, and welding	Hot sparks	Goggles, safety glasses with side shields or face shields for severe exposures	
	Splash from molten metals	Face shields worn over goggles	
	High-temperature exposure	Screen face shields or reflective face shields	
CHEMICALS—Acid and chemicals handling, degreasing plating	Splash	Goggles, eyecup, and cover-type face shields for severe exposure	
	Irritating mists	Special-purpose goggles	
DUST—Woodworking, buffing, general dusty conditions	Nuisance dust	Goggles, eyecup, and cover types	
LIGHT or RADIATION		See Chapter 16 for welding, cutting, and brazing operations	
GLARE	Poor vision	Spectacles with shaded or special-purpose lenses	

Nonmandatory Compliance Guidelines for Hazard Assessment and Personal Protective Equipment Selection, OSHA standard 29 CFR-1910.

or face shields. Workers must wear personal protective equipment over the eyes or face, when the job requires it, regardless of whether they are wearing contact lenses. In OSHA's early years rules were observed that prohibited the use of contact lenses in certain jobs. Later research led OSHA to remove these prohibitions and permit contact lens users to wear them on the job, provided appropriate personal protective equipment is used as required for nonusers of contact lenses as well. Contact lenses have some advantages over conventional glasses (with frames). The frames of conventional glasses may partially restrict the field of view and may interfere with the seal required for full-face respirators.

More important than when to *require* eye protection is how to *educate* workers to be alert to eye hazards and the long-term consequences of eye injury. The National Safety Council has some videos that bring this point home. One effective video shows emergency eye surgery in progress. Another is a poignant personal testimony of a man who was blinded on the job and the hardships he and his family have suffered since.

A final note about eye protection is a behavioral factor. Historically, people have avoided wearing glasses because of their appearance. Men and women alike have sought contact lenses to correct their vision, often for no other reason than personal appearance. The feelings about wearing glasses are complex. For men, the notion has been that glasses detract from the ruggedness of their appearance. For women, historically, glasses have somehow been thought to detract from their appeal. Toward the end of the twentieth century, those notions began to change and the wearing of glasses began to become fashionable. Television series in which beautiful models wore glasses served to usher in this change in attitudes toward glasses. Glasses manufacturers were quick to pick up on this trend, and especially safety glasses manufacturers began to feature new styles or looks in advertising and promotions. Figure 12.1 is an example for safety glasses that illustrates the appeal of physical appearance in the sale, adoption, and use of safety glasses for eye protection.

RESPIRATORY PROTECTION

Of even more vital importance (in the literal sense of the word *vital*) than eye and hearing protection is the need for respiratory protection from airborne contaminants. Chapter 9 discussed the different types of problems with industrial atmospheres, and determination of the type of atmospheric problem is essential in selecting the correct respiratory equipment. A well-designed and expensive gas mask is useless and might be more properly designated a "death mask" if the atmospheric problem to be tackled is oxygen deficiency, for example.

Particularly hazardous atmospheres may be referred to as *IDL*, which stands for "immediately dangerous to life" or *IDLH*, which stands for "immediately dangerous to life or health." Recently, the acronym IDLH has become more widely used. If a single acute exposure is expected to result in death, the atmosphere is said to be IDL. If a single acute exposure is expected to result in *irreversible* damage to health, the atmosphere is said to be IDLH. Some materials—hydrogen fluoride gas and cadmium vapor, for example—may produce immediate transient effects that, even if severe, may pass without medical attention but are followed by sudden, possibly fatal collapse 12 to 72 hours after exposure. The victim "feels normal" after recovery from transient effects until collapse. Such materials in hazardous quantities are considered to be "immediately" dangerous to life or health (Industrial Ventilation, 1978).

The World Trade Center attack and subsequent collapse taught us much about the long-term effects of inadequate respiratory protection in an environment that was

Wavebreakmedia/Shutterstock

FIGURE 12.1

Models feature safety eyewear that promotes a positive image for workers who wear safety glasses.

immediately dangerous to long-term health. When the towers collapsed, anyone in the vicinity was exposed to an array of materials that were very caustic in nature. In a study of 27,000 people impacted, there has been a significant mortality increase due to respiratory diseases and lung damage as well as increased levels of cancer (First Long-Term Study of World Trade Center Rescue and Recovery Workers Shows Widespread Health Problems Ten Years After 9-11, 2011). As time passed during the response activities of the first two weeks, there was a significant increase in the use of respiratory protection.

From the collapse to the week 2 activities the use of respiratory protection went from over 50% with no protection to less than 20% using no protection. There was also an increase from under 10% to almost 70% usage of a half-face respirator (Use of Respiratory Protection among Responders at the World Trade Center Site, 2002).

It should be apparent to the reader at this point that there is more to respiratory protection than simply handing out respirators to workers who might be exposed to hazards. Effective protection demands that a well-planned program be implemented, including proper selection of the respirators, fit testing, regular maintenance, and employee training.

Some firms supply respirators to employees without bothering with a comprehensive respirator program, relying on the excuse that the respirators are not really required anyway because contaminants in the plant atmosphere do not exceed maximum permissible exposure limits (PELs). The safety and health manager is really asking for trouble, though, by toying with a partial program. The atmospheres are no doubt marginal, or the question of a partial program would never have arisen. The marginal atmospheres might later deteriorate without warning. Employees would be lulled into a false sense of security by the superficial respirator program. Bad habits, such as negligent maintenance, inadequate fit testing, or improper equipment usage, could be developed. A whole feeling of complacency toward the use of respirators can be engendered by the use of such equipment when it is not really needed.

As with general personal protective equipment discussed earlier, the safety and health manager is often placed on the spot when employees bring their own respiratory protection equipment onto the job site. In this situation, the employer should take a responsible position and ensure that these employees use their respiratory equipment properly. If the employee resents what he or she perceives as the employer's interference, he or she should be reminded of the employer's continuing responsibility to eliminate hazards in the workplace, including misuse of personal protective equipment. If the equipment or its improper use can be hazardous, the employer can forbid the employee from bringing the equipment onto the premises. The safety and health manager may feel some hesitation in exercising such authority over the employee's own personal property, but instances have already occurred in which employers have exercised such authority when necessary to prevent hazards.

Before going further into the subject of respiratory protection, a classification of the various devices is in order. The two major classifications are *air-purifying* devices versus *atmosphere-supplying* devices. The air-purifying devices are generally cheaper, less cumbersome to operate, and the best alternative if they are capable of handling the particular agent to which the user will be exposed. However, some materials simply cannot be reduced to safe levels by air-purifying devices, and a supplied-air system is required. Another important consideration is oxygen deficiency. No amount of filtering or purifying is going to make an oxygen-deficient atmosphere safe. The only way to go in this situation is with atmosphere-supplying respirators. A summary classification of respiratory protection devices is as follows:

1. Air-purifying devices
   (a) Dust mask
   (b) Quarter mask

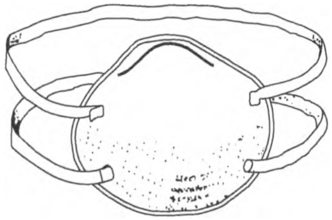


FIGURE 12.2
Disposable dust mask.

- **(c)** Half mask
- **(d)** Full-face mask
- **(e)** Gas mask
- **(f)** Mouthpiece respirator

2. Atmosphere-supplying respirators
- **(a)** Air line respirator
- **(b)** Hose mask
- **(c)** Self-contained breathing apparatus

Further description of each type of device follows.

Dust Mask

The most popular respirator of all is also the most misused. Approved only for particulates (suspended solids), the dust mask (Figure 12.2) is not approved for most painting and welding hazards, although it is frequently used improperly in this way. Some dust masks are approved for mild[1] systemic poisons, but generally these masks are limited to *irritant dusts*, those that produce pneumoconiosis or fibrosis (see Chapter 9). One of the principal limitations of the dust mask is fit. Even the best-fitting models have approximately 20% leakage. A rule of thumb is that approval is valid for particulates no more toxic than lead.

Despite its disadvantages, the dust mask is popular because it is inexpensive, sanitary, and can be thrown away after each use. Its low cost and general availability make the dust mask attractive for purchase at the local drugstore and for personal use. Therefore, this is the type of respirator that the safety and health manager is most likely to find employees bringing from home for use on the job. Care should be taken to educate employees about the limitations of the dust mask.

Quarter Mask

The quarter mask, sometimes called the type B half mask, is shown in Figure 12.3. The quarter mask looks very much like a half mask except that the chin does not go inside the mask. The quarter mask is better than the dust mask, but it, too, is generally approved for toxic dusts no more toxic than lead.

[1]Dusts that have a threshold limit value of not less than 0.05 mg/m^3.

FIGURE 12.3
Quarter mask.

FIGURE 12.4
Half mask.

Half Mask

The half mask, shown in Figure 12.4, fits underneath the chin and extends to the bridge of the nose. This mask must have four suspension points, two on each side of the mask, connected to rubber or elastic about the head.

Full-Face Mask

Actually, the gas mask is also *full face*, but the name *full-face mask* generally refers to a mask in which the filtering chamber attaches directly to the chin area of the mask. The filters may be either dual *cartridges* or single *canisters*. Both types are shown in Figure 12.5. Canisters contain granular *sorbents* that filter the air by adsorption, absorption, or chemical reaction.

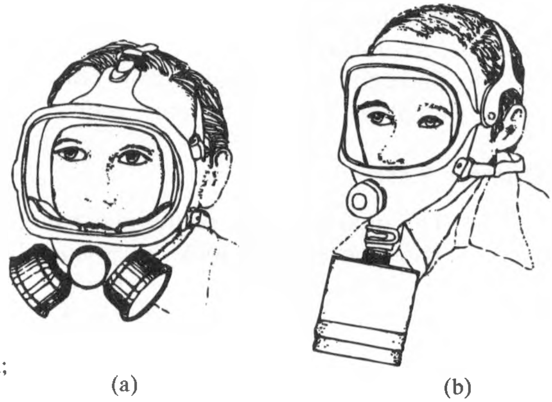


FIGURE 12.5
Full-face masks: (a) dual-cartridge full-face mask; (b) canister-type full-face mask.

FIGURE 12.6
Gas mask.

Gas Mask

The gas mask is designed for filtering canisters that are too large or too heavy to hang directly from the chin. In the gas mask, the canister is suspended by its own harness and is typically connected to the face mask by a corrugated flexible breathing tube. The gas mask is shown in Figure 12.6.

Mouthpiece Respirator

Perhaps the mouthpiece respirator should be omitted from this discussion because this type of device is not intended for normal use. However, emergencies will occur from time to time, and enabling the user to be prepared to escape during such an emergency is the purpose of the mouthpiece respirator. Breathing is accomplished through the mouth by means of a stem held inside the teeth. A nose clip must be used to prevent inhaling through the nose. It is possible to form a good seal with the mouth and lips, but the effectiveness of the mouthpiece respirator is greatly dependent on the knowledge and skill of the user.

Air Line Respirator

The air line respirator is an atmosphere-supplying respirator and derives its name from the way in which air is supplied to the respirator mask. The air is supplied to the mask by a small-diameter hose (not over 300 feet long), which is approved together with the mask. Ordinary garden hose is not acceptable. The air is supplied by either cylinders or compressors. The method of delivery of air to the user results in three different modes of air line respirator: continuous flow, demand flow, and pressure demand.

In the *continuous-flow* mode, the air line respirator receives fresh air without any action on the part of the user, that is, the flow is forced by the apparatus. The airflow must be at least 6 cubic feet per minute to qualify a hood for use with this mode. The flow should not be much greater than this because it can induce a high noise level inside the hood. One of the advantages of the continuous-flow mode, however, is that it permits use of a somewhat leaky, loose-fitting hood. The positive pressure differential between the inside and outside of the hood keeps the flow outward, preventing toxic agent entry. The continuous-flow mode needs an unlimited supply of air, so a compressor is used instead of tanks.

In the *demand-flow* mode, air does not flow until a valve opens, caused by a negative pressure created when the user inhales. Exhalation, in turn, closes the valve. This mode has the advantage of using less air, so it is feasible with cylinders. However, the disadvantage is the need for a tight-fitting facepiece. Since inhalation causes a negative pressure differential to develop, a leaky facepiece will readily draw in the toxic ambient atmosphere. In fact, if the facepiece is too leaky, the inhalation valve will fail to open, making use of the facepiece even more hazardous than not using personal protective equipment at all. For this reason, the demand-flow mode is becoming obsolete and is being replaced by the third mode: pressure demand.

The *pressure-demand* mode has features of both the continuous-flow and pressure-demand modes. As in the continuous flow, a positive pressure differential is maintained by a preset exhalation valve. Despite its advantages, the demand-flow mode still requires a well-fitting mask; use by a person with a beard is not acceptable.

Hose Mask

A hose mask is a somewhat crude form of an air line respirator. The diameter of the hose is larger than in the air line respirator, permitting air to be inhaled by ordinary lung power. A blower is sometimes used as an assist. The hose mask is declining in popularity.

Self-Contained Breathing Apparatus

In this type of respiratory protection, the user carries all of the apparatus with him, usually on his back. This has the advantage of increasing the distance the user can roam because there is no umbilical cord to drag along and perhaps sever or crush. However, a disadvantage is that the large pack on the back may restrict the passage of the user through a manhole or other close passage. Engineers should consider this problem when designing manholes for vessel entry when toxic atmospheres may be a problem. Many fatalities have occurred when rescue breathing packs were rendered useless because the rescuer was unable to enter the vessel with a breathing pack on his back as Case Study 12.1 will illustrate.

The scenario described in Case Study 12.1 is not unusual. The hazards of confined space entry have prompted OSHA to promulgate a standard on this subject, to be covered in a later section.

CASE STUDY 12.1

CONFINED SPACE ENTRY

An employee of a zinc refinery was working in a zinc dust condenser when he collapsed. Another employee donned a self-contained breathing apparatus (SCBA) and attempted to enter the condenser to rescue the downed employee. He was not able to fit through the portal wearing the SCBA, so he removed it, handed it to another employee, and then entered the condenser. He planned to have the other employee hand the SCBA to him through the portal, redon it, and then continue with the rescue. He collapsed and fell into the condenser before he could redon the SCBA. The first employee was declared dead at the scene; the would-be rescuer died 2 days later. The toxic air contaminant was later determined to be carbon monoxide (OSHA fatality case history).

Most self-contained breathing apparatus units at the present time are *open circuit*, that is, the exhaled breath is discharged to the atmosphere (see Figure 12.7). *Closed-circuit* units recycle the exhaled breath, restoring oxygen levels. The advantage of the closed-circuit types is that the pack can be much smaller and lighter per minute of maximum permissible use. Some closed-circuit types (see Figure 12.8) have a small high-pressure oxygen tank for restoring oxygen levels after carbon dioxide is removed. Other closed-circuit types use a chemical reaction to restore oxygen levels, making possible a very

FIGURE 12.7

Open-circuit self-contained breathing apparatus.

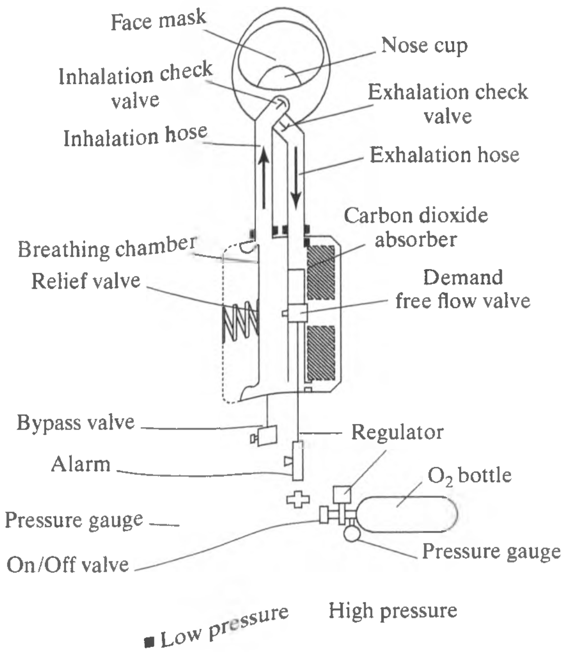


FIGURE 12.8

Closed-circuit self-contained breathing apparatus (oxygen bottle type).

compact unit. The source of the oxygen is a superoxide of potassium in which oxygen is liberated by mere contact with water. The water is supplied by the moisture in the user's exhaled breath. It takes a little while for the chemical process to function and become balanced, so the user should prime the system while still in clean air before entering the hazardous zone. A hazard with the chemical oxygen-generating unit is that the potassium superoxide must be kept sealed from moisture, except for the small amount of moisture in exhaled breath. A water flooding of the potassium superoxide unit's interior is almost sure to cause an explosion. Another hazard with the chemical oxygen-generating unit is that it supplies an oxygen-rich atmosphere, and this can be a fire hazard.

Respirator Plan

The long list of available types of respiratory protection may bewilder the safety and health manager who must choose which type of protection is optimum for each application. Adequate planning for respirators and their appropriate use, maintenance, and the training of employees who will wear them is an important OSHA requirement. Expert consultants can help in this situation, but the safety and health manager should assure that OSHA required ingredients for respirator plans be included. OSHA standard 1910.134(c) sets forth these necessary steps, summarized here as follows:

1. Procedures for respirator SELECTION
2. Medical evaluations for respirator users—PERSONNEL SCREENING
3. Respirator FIT TESTING
4. Procedures for proper USE of respirators
5. Procedures for respirator MAINTENANCE
6. Provision of adequate SUPPLIED BREATHING AIR for air-supplying respirators
7. Employee TRAINING for when respirators are needed
8. Employee TRAINING for proper wearing, use, and maintenance of respirators
9. Procedures for continuing EVALUATION of the respirator program

The ensuing sections of this chapter will assist the safety and health manager to implement the required steps for a respirator plan, beginning with selecting the appropriate respirator for the task.

Respirator Selection

One simplifying factor in the selection of respirators is that the hazard usually dictates the choice of device or at least greatly narrows the field of choice. Devices are approved for particular concentrations of particular substances, and unapproved devices must not be used.[2] Consultants can help to select between approved respirators, considering efficiency, cost, convenience, and other factors.

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[2]For approval of respirator devices, see *NIOSH Certified Equipment, Cumulative Supplement* (NIOSH 77–195), June 1977, and subsequent issues available periodically from NIOSH Laboratories in Morgantown, West Virginia.

Sometimes the excuse is offered that no approved device exists for a particular toxic substance. However, this excuse is a poor one because the worker must somehow be protected from dangerous atmospheres. There are many different kinds of respiratory equipment, just as there are many different types of respiratory hazards. It may be true that there is no *approved* device of a particular type for a given hazard. For instance, the employer may want to use some type of respirator for a hazard that has no approved respirator as such, but another type of device *could* be used. An example would be the hazard of mercury vapor. No air-purifying device is acceptable for protection against the hazards of mercury vapor. Mercury vapor offers no warning odor or other means to detect when the canister is no longer effective. So with mercury vapor, the employer must turn to another type of protection, such as air line breathing equipment. Thus, for every hazardous atmosphere in which an employee must work, there must be an approved device of *some type* to protect the worker. If there is no approved device for the given hazardous contaminant, workers must be prohibited from the area.

Determining the approval status of a device for a particular respiratory hazard is no easy task. The approval authority is complicated and has frequently changed from agency to agency. Furthermore, the equipment approval lists are continually being updated. A practical solution to the problem is to seek the advice of the manufacturer of the equipment, for the obvious reason that the equipment manufacturers are likely to be most aware of the approval status of their own equipment. Not as worthy of trust is the local equipment distributor. With no reflection on the character of the local equipment distributor, such persons often carry so many lines of safety equipment that it is impossible for them to be as intimately aware of the various toxic substance approval limitations of each respiratory protection device as will be the manufacturer of the given device.

Complicating the situation is the misleading nomenclature. For instance, *organic vapor respirators* are not necessarily acceptable for commonly encountered organic vapors. Methanol, for instance, is not readily absorbed by any cartridge, and only air line equipment is effective for protection against hazardous concentrations of methanol. It is unfortunate that federal regulations require a respirator to be identified as an organic vapor respirator because it has passed a certain prescribed test, even though the respirator may be useless for certain organic vapors. Workers are not even protected by warning labels that their organic vapor respirators may not be effective for the organic vapors with which they are working. The same is true for gas masks.

Why does such a confusing and misleading system exist? Part of the problem is the complexity of organic chemistry and the myriad hydrocarbon compounds that exist. If the manufacturer attempted to label each cartridge with all the organic compounds for which it was effective, there would soon be no space on the cartridge for anything else. Any kind of shorthand coding system might confuse users in the field. Furthermore, an attempt to itemize would imply that the list was exhaustive, and the user might check no further to see whether a particular cartridge might be effective against a given substance. So again the best course of action is to check with the manufacturer for more complete and detailed lists of substances for which the organic vapor respirator cartridge is effective.

A basic principle of respirator selection is never to select a gas-absorbing respirator for use with a gas that has no distinguishing warning properties. A moment's reflection will reveal the logic behind this principle. All respirator cartridges eventually become saturated or loaded to the extent that they are no longer effective. The users will know automatically when that point is reached through their own senses of smell, taste, or perhaps an irritation or other sensory warning, depending on the properties of the dangerous gas. However, if the toxic gas has no sensory warning property, the users will never know and may be subjected to dangerous exposures while wearing an approved respirator.

A good example of such misuse is use of half-mask respirators by a typical roofing company when applying expandable foam. Unfortunately, the organic substances present in expandable foam do not have adequate warning properties, and there is no air-purifying device approved for such use. Therefore, air line respirators should be used.

There is one exception to the rule that air-purifying devices cannot be used with gases that do not have warning properties capable of being sensed by the user: when canisters can be equipped with an effective end-of-service-life indicator. Currently, such canisters are available for carbon monoxide (type N canisters).

Paint, lacquer, and enamels cartridges offer protection from both the particulates and the organic solvents in the paint. Actually, the organic vapors represent the real hazard with paint, lacquer, and enamels respirators. Except for lead-based paint, the particulates in paint are not the principal problem.

Welding operations present special problems because toxic gases or fumes, or both, are often encountered, while at the same time, the welder must be protected from harmful rays. Snap-on lenses are available for full-face respirators to protect against harmful rays. Another alternative is to wear the respirator beneath the hood. This requires a special welding hood, and only a half-mask respirator can be worn under this hood.

Respirator cartridges are not like vacuum cleaner bags; they cannot be changed from manufacturer to manufacturer without approval. The cartridge and the respirator must be approved together as a unit, although it would be possible for a respirator of one make and a cartridge of another make to be approved together if the specific combination was subjected to approval testing. Public controversy over cartridge refill approvals has charged that manufacturers have monopolistically promoted safety regulations to protect sales of their own products. On the other side of the issue is the argument that cartridge fit and proper seal are critical to the effective operation of the respirator.

Personnel Screening

For jobs requiring the use of respirators, a determination should be made to be sure that persons are "physically able to perform the work and use the equipment. The local physician shall determine what health and physical conditions are pertinent." This sounds costly and time consuming, but there is a shortcut that can expedite the personnel screening process, eliminating a large majority of the problem cases. The shortcut is to use a questionnaire that can identify obvious problems before employing a person in a job that requires respirators. Any questionnaire that is used to place employees properly should be used carefully so as not to be construed as a mechanism for discrimination against the handicapped. In earlier chapters, we examined the provisions of the Americans with Disabilities Act (ADA) (Public Law 101–336, 1990) that prohibit discrimination in preemployment medical examinations that work to discriminate against the handicapped. However, if the employer properly documents the job-specific requirements in occupations that require respirators and ensures that all candidates are examined for these physical characteristics, problems with ADA will be avoided.

A variety of physical conditions makes a person unfit for respirator use, whereas that person might be quite well suited to a job that does not require such use. The U.S. Nuclear Regulatory Commission lists some of the physical conditions that should be included in a questionnaire for screening workers from jobs requiring the use of respirators. Asthma and emphysema are pulmonary problems that may result in problems with respirators. If the environment requires self-contained breathing apparatus, the potential employee may not be fit for carrying the heavy equipment because of a back injury history or heart disease. Another physical problem is ruptured eardrums. A person with a ruptured eardrum actually breathes through his or her ears. Thus, a face mask respirator that does not cover the ears may offer little in the way of protection. Epilepsy is another potential problem. Epileptics are often on medications that themselves can present some hazards. In addition, the possibility of a seizure presents the threat of the respirator being removed at the wrong time. Diabetics may also be on medications, and the use of respirators may interfere with such medications. These individuals, for instance, would probably be a poor choice for a rescue team. Even psychological factors such as claustrophobia may be important to consider. The employee questionnaire can be a source of protection from future liability in case physical problems are present. The questionnaire should be developed with the assistance of a physician. If physical problems or variations are revealed by the preliminary questionnaire, the employee should be examined by the physician for a final determination.

Fit Testing

If the respirators to be used are not of the continuous flow type, fit testing becomes essential to assure a tight seal between the face and the respirator. Fit testing, or leak testing, is an essential element of an effective respirator program. Facial characteristics vary significantly, and fit tests are necessary to determine which particular model fits each worker best without appreciable leaking. Even the best respirators on the market will fit only a percentage of workers. Other respirators must be selected for other facial shapes.

One facial shape that is impossible to fit is the bearded one. A beard should be prohibited for any worker who must wear a fitted respirator for his safety and health. Two firemen in Los Angeles filed a discrimination suit when they were laid off because they wore beards. Their job required the possible use of self-contained breathing apparatus. The firemen lost their case. The argument against facial hair on jobs requiring respirators is well documented. When the wearing of a beard is a religious matter, the issue becomes more complicated (Claussen, 2008). Civil rights law obligates the employer to make an accommodation for an employee's religion when such beliefs clash with work practices. It may be possible to reassign an employee to another job within the company that does not require the employee to wear a fitted respirator. If this is impossible or impractical, the employer may be exempted from the requirement due to "an undue hardship" on the employer. What constitutes an undue hardship? If the worker's safety is compromised, or even if coworkers are forced to carry the load of bearing the accommodated worker's potentially hazardous work, there may be a basis for claiming undue hardship. OSHA has exempted workers from being required to wear hard hats if doing so conflicts with their religious beliefs unless the hazard is particularly "grave."

Respirator fit testing seems to imply expensive environmental chambers, but such chambers are not required. Some consultants recommend a simple plastic clothes bag suspended over the wearer's head. The subject's respirator should be equipped with an organic vapor cartridge, and the air inside the bag is contaminated with isoamyl acetate (available from the local pharmacy). If the subject smells the familiar "banana oil" odor, his or her respirator is leaking. Once fit-tested for a particular make and model of respirator, every respirator of the same make and model is acceptable for that user.

One ironic development in the field of respiratory protection is NIOSH's discovery of evidence suggesting that the substance di-2-ethylhexyl phthalate (DEHP) is a potential carcinogen. The irony is that DEHP had been used as a test agent for determining the fit of respirators!

Systems and Maintenance

For air supplied by compressors, care should be taken to select a *breathing-air* type of compressor. What to avoid is the use of the ordinary mechanical tool air compressor for this purpose. Pneumatic tools are sometimes lubricated through a system of injected lubricants into the supplied air. This, of course, would not be satisfactory for breathing purposes.

Some confusion exists over "alarms" required for compressor failure or overheating. The reason alarms for overheating are needed is that a hot compressor can deliver deadly carbon monoxide to the air line respirator user. Some breathing-air compressors have automatic shutdowns instead of alarms, and this is entirely satisfactory for some types of industrial environments. For instance, abrasive blasting atmospheres are not IDLH (immediately dangerous to life or health), and if the compressor overheats and shuts down, workers can merely take off their respirators and immediately leave the area. However, in an IDLH atmosphere, a compressor shutdown could result in a fatality, and an alarm is needed.

Respirators are subject to deterioration from improper maintenance, and, in addition, they can simply become unsanitary. A routine inspection before and after each use can be performed by the users themselves. These routine inspections could include a check for cleanliness, deterioration, and obvious function.

Self-contained breathing apparatus units should have an effective monthly inspection. The regulator should be pressurized to determine whether the low-pressure warning device operates. Cost for loss of pressurized air should not be an important factor because it should take less than 50 pounds of air to perform a complete check. Tanks should be pressurized to at least 1800 psi. Both the cylinder and the regulator have a gauge. Instead of trusting the cylinder gauge, the regulator should be pressurized and the gauge verified.

The self-contained breathing apparatus unit is usually reserved for emergency use, not ordinary on-the-job use. The whole idea of emergency respirators is serious business because in an emergency, there is a high probability of IDLH atmospheres. Emergency rescue equipment in IDLH atmospheres demands high-quality equipment, carefully inspected and maintained and effectively used by trained rescue teams.

CONFINED SPACE ENTRY

One of the most dangerous jobs in industry is cleaning, repair, or maintenance that requires entry inside a tank or other confined space. The hazard is heightened by the fact that the inside of a tank is not designed for continuous occupancy; therefore, the environment is usually suspect. Since the operation is temporary, the temptation is to take chances and hope for the best. Even if the atmosphere is known to be marginally dangerous, workers are tempted to "get in and get out in a hurry" to get the job done without the time and expense of extensive and comprehensive personal protective equipment. With this frame of mind, let us examine Case Study 12.2.

CASE STUDY 12.2

HYDROGEN SULFIDE POISONING

A maintenance worker entered a sewer manhole to repair a pipe and collapsed at the bottom. A coworker, who had been observing the initial entrant, entered the manhole, lost consciousness, and fell to the bottom. A supervisor looked into the manhole, saw the would-be rescuer, and entered to attempt rescue. The supervisor became dizzy, climbed from the manhole, and passed out. When he regained consciousness, the supervisor summoned rescue and emergency services. Both the initial entrant and the first would-be rescuer died of hydrogen sulfide poisoning (Federal Register, 1993).

Almost a quarter of a century later, a similar issue occurred when a utility company was working on a sewer. Without checking the atmosphere, a maintenance technician entered and went silent, then another entered to check on him with the same result, and finally a third entered. A firefighter responded on the scene and could not fit his gear into the hole and had the same result. The three maintenance technicians died and the firefighter almost lost his life in the incident (Schmidt, 2017).

By using hindsight, it seems that the second and third workers should have known better than to enter the confined space after the first worker was overcome. However, Case Study 12.2 is not an isolated incident. Double- and even triple-fatality incidents of this type are fairly common. In the heat of the emergency, there is a strong tendency to try to save the victim, and somehow our reasoning process tells us that what happened to the first worker would not happen to us. Apparently, we think that we will be more alert to the symptoms than was the first victim, and we will get out quickly as soon as we become aware that we are falling into the same fate.

OSHA has taken a keen interest in this hazard, and for many years, it collected data, opinions of industry and labor representatives, and suggested wordings for a standard specifically addressing confined space hazards. Meanwhile, it continued to investigate such fatalities and cite employers, usually reverting to the General Duty Clause of the OSHA law. In 1993, OSHA promulgated a confined space standard that crystallized industry thinking regarding what must be done to prepare for and avoid the hazards of confined spaces.

According to OSHA, three conditions must be met for a space to be designated a "confined space":

1. Limited openings for entry and exit.
2. The space must not be intended for continuous human occupancy.
3. The space must be large enough to enter and do work.

If a work space meets all of the above criteria, the safety and health manager should identify the hazards involved and make sure that all required procedures are followed. Even if there are multiple openings for entry and exit, the workspace may still be a confined space if the size of the openings is limited.

Identifying the Hazard

Confined spaces have more hazards than most people think. The principal hazard is the atmosphere that the worker breathes inside the space, but this is by no means the only problem to consider. Some confined spaces represent a mechanical hazard, such as the nightmare of a descending and ever-tightening constricting space that may trap the worker, making any movement to escape only a further aggravation of the problem until the worker is hopelessly ensnared in a space of suffocating dimension. The hazard of *entrapment* in such places as silos, tapered storage bins, hopper feeders, and cyclone collectors (see Figure 10.5) is real and even commonplace in agricultural and material processing industries.

Another hazard that has nothing to do with the atmospheric quality in a confined space is *engulfment*. Sand, grain, and other granular dry solid material can have fluid-like properties, and a person can become effectively captured or surrounded by it while sinking deeper with every movement. Death can come in at least two ways: The worker can breathe the dust or other material particles and the breathing passages can become blocked, or the worker may even be crushed by the weight of the material closing in around him or her (see Case Study 12.3).

CASE STUDY 12.3

SAND ENGULFMENT

Two Ohio foundry employees entered a sand bin to clear a jam. While they were working, sand that had adhered to the sides of the bin began to break loose and fall on them. One employee quickly became buried up to his chest, just below his armpits. The other employee left the bin to obtain a rope, intending to use it to pull his coworker out of the sand. He returned to the bin, tied the rope around the partially buried employee, and tried to pull him free. He was unsuccessful. During his attempted rescue, additional sand fell, completely covering and suffocating the employee who had been only partially buried (Preamble to the OSHA Lockout/Tagout Standard, 1981).

Although engulfment is a serious hazard to be considered, simple oxygen deficiency (less than 19.5% oxygen in breathing air) is likely the biggest killer in confined spaces. Oxygen deficiency often arises from chemical processes that react with oxygen in the air, such as fermentation, combustion, and even corrosion. Sewers and sewer processing facilities are often found to be oxygen deficient. It is ironic that *inerting*, a procedure intended for enhancing fire safety, causes a different hazard—oxygen deficiency. Nitrogen or other inert gas is used to displace oxygen in an atmosphere that might have dangerous concentrations of flammable gases or vapors. Too little oxygen is a hazard, but so is too much. Oxygen has a density slightly heavier than normal breathing air, so oxygen enrichment (oxygen content greater than 23.5% in breathing air) can present problems in such confined spaces as missile silos. In Chapter 16, we shall see how this hazard led to one of the worst industrial accidents in the history of the United States. Wherever welding is done, and it is often done in confined spaces, the possibility of fires being generated in oxygen-enriched spaces must be considered.

Earlier in this chapter, we considered the usual definition of the term *IDLH*; now, with respect to confined spaces, we must add another facet to this definition—the problem of escape. Thus, even if an atmosphere has no immediate effects on life or health, if it temporarily paralyzes the worker or impairs his or her ability to escape, it becomes IDLH for the confined space.

Isolation of the Space

It is obvious that a space that normally contains a liquid, especially a liquid that issues toxic vapors, must be removed from the tank or other confined space before entry. In addition, it is elementary that piping valves that normally deliver the dangerous liquid to the space must be closed. However, the hazard is more insidious when a confined space is involved. Even though a pipe valve may be closed, if there is high pressure behind the valve, there may be a small amount of leakage or *bleeding* into the space to be entered. This has led to a recognized safety procedure known as *double block and bleed*, described further in Figure 12.9.

Another practice that accomplishes the same objective as double block and bleed is to sever or separate the line and misalign it to physically break continuity between the confined space and the hazardous material. Another solution is *blanking* or *blinding*, which means the absolute closure of a pipe, line, or duct by the fastening of a solid plate that completely covers the inside cross section of the pipe and is capable of withstanding the maximum pressure of its contents without leakage.

One of the most hazardous operations in confined spaces is welding. Often, tanks must be entered for welding repairs; and the potential for igniting hazardous atmospheres when welding in confined spaces adds an additional hazard beyond all the other hazards associated with confined spaces. Because welding has special hazards and is an important subject from both a health and a safety perspective, Chapter 16 is devoted entirely to welding processes and associated hazards, including confined spaces.

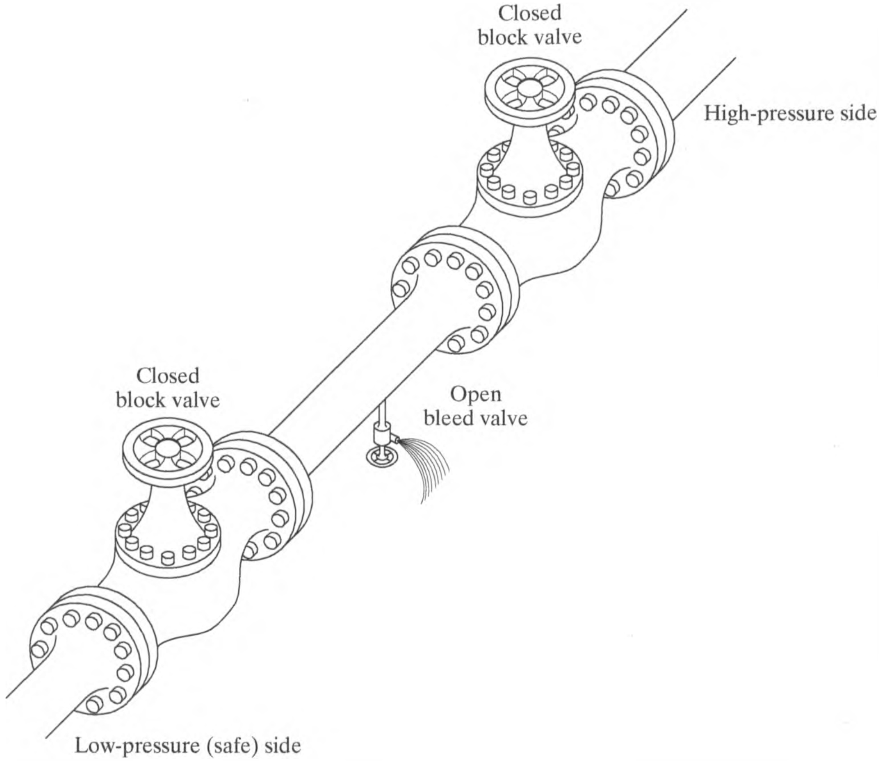

FIGURE 12.9
Double block and bleed.

HEAD PROTECTION

A primary symbol for OSHA, corporate safety departments, and just about anything related to occupational safety and health is the familiar profile of the "hard hat." So important is the symbol that many zealous safety managers have established sweeping hard-hat rules throughout large general work areas. There is nothing wrong with such rules if a genuine hazard exists. However, when workers sense that no hazard exists and that the hard-hat rule exists as a promotional device or for window dressing, they often show their defiance by refusing to wear the hard hat.

Hard-hat rules should be carefully formulated with ample consideration for the consequences both ways. Once it has been decided that a hard-hat rule is necessary, the safety and health manager should take steps to ensure its implementation. The evidence that was used to prove the need for the hard-hat rule should be compiled into organized training packages to convince workers. After the training and launching of the implementation phase, follow-up checks should be used to ensure that the rule is being followed. Corrective steps should be taken to overcome individual violations of the rule, including disciplinary actions if necessary.

Hard hats seem to have won wider acceptance than hearing protection. Besides being a symbol for occupational safety and health, the hard hat has become a symbol for rugged, physical jobs. This image has appealed to males for centuries and is becoming an increasingly appealing image for the female worker also. Management personnel have also coveted the image conveyed by the hard hat. A hard hat worn by a manager seems to imply that the manager is well founded in the operations of the enterprise and is action oriented, doing more than talking on the telephone, attending meetings, and sitting behind a desk.

MISCELLANEOUS PERSONAL PROTECTIVE EQUIPMENT

Safety Shoes

Safety shoes are a more expensive undertaking than hard hats because safety shoes get worn out faster and are more expensive per item. Employees may buy their own shoes at attractive discounts in some arrangements, and this encourages actual use. Safety shoes come in a wide variety of appealing styles, and employee resistance to wearing safety shoes is largely a thing of the past.

The safety and health manager is usually saddled with the decision as to which jobs require safety shoes and which do not. Although applicable national standards are explicit about the design and construction of safety shoes, as with almost all personal protective equipment, the decision of where such shoes must be worn is left up to either the user or management.

OSHA Standard 1910.136 requires that all protective footwear be compliant with any of the below consensus standards:

- ASTM F-2412-2005 and ASTM F-2413-2005
- ANSI Z41-1999
- ANSI Z41-1991

The standard also allows for a performance compliance approach where protective footwear is at least as effective as any of these standards. Protective footwear should be used "where there is a danger of foot injuries due to falling or rolling objects, or objects piercing the sole, or when the use of protective footwear will protect the affected employee from an electrical hazard." ANSI is quite specific about the requirements of the standard. These can be found on the tongue of compliant safety shoes. The requirement is the ability of the toe to withstand an impact of 75 foot-pounds and a compression force of 2500 foot-pounds.

One place where safety shoes are clearly needed is on shipping and receiving docks. This should be obvious, but there has been some legal controversy over this issue. The courts have settled the question, and safety and health managers should ensure that shipping and receiving dock personnel wear safety shoes.

Protective Clothing and Skin Hazards

Occupational skin disease, especially contact dermatitis from irritants to the skin, represents a significant number of all occupational diseases reported. The safety and health manager should be alert to several skin hazard sources, such as welding, special chemicals, open-surface tanks, cutting oils, and solvents.

Most welders know the value of heavy-duty protective aprons and flameproof gauntlet gloves. Leather or woolen clothing is more protective than cotton from a burn ability standpoint. Nomex™ is a treated flame-retardant fabric.

Another concern for protective clothing is chemical exposures from open-surface tanks. Gloves must be impervious to and unaffected by the liquid being handled and long enough to prevent the liquid from getting inside. If the gloves are not long enough, they can be more hazardous than beneficial. Many workers' hands have become more irritated than their unprotected arms simply because the gloves they were wearing permitted liquids to get inside, turning the gloves themselves into dip tanks for the hands!

Discussion of personal protective equipment for open-surface tanks is not complete without mention of *chrome holes*, an ominous-sounding affliction that comes by its name honestly. Vapors and mists from chromium plating tanks can cause open ulceration, particularly in moist, tender parts of the skin. The inner septum of the nose—that part which divides the nostrils—is particularly susceptible to ulceration from chromic acid, sodium chromate, and potassium dichromate. In plating plants, it is not unusual to find workers whose nasal septums have been completely destroyed by these chromium compounds. Proper ventilation and engineering controls are the most appropriate means of prevention. Worker education and regular examination can also be helpful, including periodic examination of the nostrils and other parts of the body for workers exposed to chromic acids. As with other hazards, the last line of defense would be personal protective equipment in the form of respirators with cartridges to remove the dangerous chromic acid mists.

Easily the most common hazards among skin irritants are the metalworking fluids used in metal machining operations. Skin irritation is not the only hazard associated with metalworking fluids, and a discussion of some of the other hazards can be found in Chapter 15. Metalworking fluids are useful and sometimes essential to lubricating the tool, reducing cutting temperature, removing chips, permitting higher-quality cut, and lengthening tool life. However, metalworking fluid is not always required and is even not desirable in some situations. The manufacturing engineer usually makes the metalworking fluid decision for the various manufacturing processes, but there is no reason that the safety and health manager should not have some input in this decision, especially since it affects safety.

Metalworking fluids are basically of four types: natural (straight oil), soluble oil, semisynthetic, and synthetic (Metalworking Fluids: Safety and Health Best Practices Manual, 2001). The natural fluids are petroleum based and are the chief culprits in a very common industrial skin disease: oil folliculitis. Oil folliculitis is basically a clogging of hair follicles in the skin, which results in acne-like lesions. The synthetic fluids are easily recognized by their milky white appearance and have gained widespread use. Although the synthetic oils are not likely to cause folliculitis, they do have a nasty reputation for becoming contaminated with bacteria, presenting the hazard of skin infections. If antibacterial agents are added, these, too, can be skin irritants. Technology is working to improve metalworking fluids, but the job is not complete. It appears that personal protective equipment is still in order.

Protective barrier creams for the skin are an alternative to gloves or protective clothing, but these creams are by no means a panacea. The creams must be removed and reapplied at least every break, every lunch hour, and every shift. Applying and reapplying creams cost labor time as well as the cost of the creams themselves. In addition, creams are not considered as effective as gloves, even when properly applied. Creams can be used, however, when the requirements of the job make gloves infeasible.

A chief concern of the safety and health manager with regard to protection of the skin is the use of various solvents within the plant. Solvents are essential for removal of grease and cutting oils, and herein lies another reason for doing without cutting oils if practical. A familiar solvent is trichloroethylene, and it is bad practice for workers to wash piece parts in trichloroethylene with their bare hands. Alternatives would include the use of wire baskets for handling the parts in the solvent, or perhaps simply substituting soap and water for trichloroethylene in some situations. For the most part, soap and water will not be effective against the oils and greases encountered, although in some situations, soap and water washing is effective. The safety and health manager is not doing the job unless he or she seeks out these situations and calls them to the attention of management and engineering. When alternative solvents, wire baskets, and other engineering controls are infeasible, personal protective equipment, such as gloves, is in order.

It seems appropriate to conclude a discussion of skin hazards, gloves, and protective clothing by mentioning one of the simplest personal protective measures of all—personal cleanliness and hygiene. Workers who are fastidious about washing their hands and bodies have frequently been found to enjoy a lower incidence of skin disease. It is easy to understand why this is so. With skin irritants, the amount of injury is generally directly related to the duration of exposure, other factors being equal. It is easy to forget how effective soap and water are in removing injurious elements of all kinds.

What can the safety and health manager do to motivate workers to adopt good habits of washing and personal hygiene? The obvious answer is training and motivational reminders in the form of signs and posters around the plant. However, this obvious answer is not the only answer and perhaps is not even the best answer. The safety and health manager can attempt to influence the selection and layout of convenient, well-maintained, pleasant restrooms that will boost employee morale while encouraging workers to wash regularly. It is discouraging for employees to encounter a washroom without warm water, soap, or towels.

FIRST AID

The safety and health manager will frequently be responsible for the first-aid station and may supervise a plant nurse. The first-aid station may satisfy several additional functions besides providing immediate care for the injured. The first-aid station is often used for medical tests, screening examinations, and monitoring of acute and chronic effects of health hazards. In addition, the plant nurse or other first-aid personnel may be responsible for performing some of the recordkeeping and reporting functions discussed in Chapter 2.

One adequately trained first-aid person is required in the absence of an infirmary, clinic, or hospital "in near proximity" to the workplace. No one seems to be able to determine authoritatively what constitutes *near proximity* in this context. Various interpretations around the country have been compared on this point, and the opinion has for the most part varied from 5 to 15 minutes of driving time. The interpretation has sometimes depended on whether the route to the hospital crosses a railroad track. If the workplace is not itself a hospital or clinic or is not directly adjacent to one, the safety and health manager is advised to be sure that at least one, preferably more than one, employee is adequately trained in first aid.

A first-aid kit or first-aid supplies should be on hand, and the safety and health manager should seek a physician's advice regarding the selection of these materials. Unfortunately, medical doctors are hesitant to give such advice, probably because they fear subsequent involvement in litigation should an accident occur for which adequate materials are not available. Safety and health managers should do their best to obtain such advice and then document what was done to obtain information.

Another first-aid consideration is the provision of emergency showers and emergency eyewash stations on job sites where injurious corrosive material exposure is a possibility. Almost everyone has seen the deluge-type shower, which is activated by grabbing and pulling a large ring attached to a chain that activates the valve. Eyewash facilities are similar to a drinking water fountain in which two jets are provided, one for each eye.

Noting the cost and permanence of a conventional eyewash facility, some enterprising and innovative individuals have marketed a simple plastic water bottle and plastic tube hanging on a frame that identifies its purpose as an emergency eyewash. Such a solution is probably not what the drafters of the standard had in mind, but the little water bottle is not without merit. For one thing, water bottles can more easily be deployed to the best spots to permit instant use in case of an accident. Most workplace layouts change rather frequently, making the permanent eyewash installation cumbersome, expensive, and often in the wrong place. Furthermore, the water-bottle approach permits convenient introduction of antidotes or neutralizing agents for specific corrosive materials. However, woe be to the injured who uses an antidote for acid when the exposure was caustic, or vice versa. In addition, the volume of water in the bottle is usually limited to 1 or perhaps 2 quarts. This may not be enough water if a first-aid manual specifies flushing the eyes "with copious amounts of water for 15 minutes."

SUMMARY

Reflection on this chapter leaves the impression that the proper provision and maintenance of personal protective equipment and first aid is not an easy task. Even after the proper equipment has been selected and procedures set up for maintenance, employees must be trained and disciplined to use the equipment properly. Inspectors can easily recognize simple violations, such as failure of individual employees to wear prescribed personal protective equipment. One pitfall for the safety and health manager is the blanket specification of personal protective equipment when its necessity is marginal. Such blanket specification is a trap that will lead to employee apathy and subsequent violation of the rule.

Returning to the principle that personal protective equipment is a last resort method of protecting the workplace, engineering the hazard out of the workplace is definitely preferred. Personal protective equipment seems to be the easy and less costly way out, but an examination of the principles and pitfalls of personal protective equipment is a strong motivation toward engineering controls.

EXERCISES AND STUDY QUESTIONS

12.1 Who is responsible for determining whether personal protective equipment (PPE) is needed in a particular workplace?

12.2 Besides needs assessment, what other general requirements for the employee use of personal protective equipment are required?

12.3 What conditions might precipitate the need for retraining in the use of personal protective equipment?

12.4 Explain possible hazards associated with attaching a safety line to a worker's belt to protect the worker from an accidental fall.

12.5 Identify resources to assist the employer in determining when and which types of personal protective equipment would be needed for a particular work site.

12.6 Under what circumstances is the employer required to train workers in the proper use of personal protective equipment?

12.7 One limitation of personal protective equipment is adequacy for the hazard for which it is intended. What is another limitation of such equipment for which the user needs training?

12.8 How might the employer be called upon to prove that employees have been properly trained in the use of personal protective equipment?

12.9 How effective is the use of cotton balls in the ears to protect against the hazard of workplace noise?

12.10 Identify the most effective form of PPE for hearing protection in the most severe noise environments. What additional benefit, besides hearing protection, is offered by this type of PPE?

12.11 Roofing workers often apply expandable foam materials using half-mask, canister respirators. Why is this basically an incorrect and unsafe practice?

12.12 What is a chemical oxygen-generating unit? Under what conditions will it explode?

12.13 As a safety engineer, under what circumstances would you recommend a closed-circuit respirator?

12.14 In an IDLH situation, would you favor demand-flow mode or pressure-demand mode if both are feasible choices? Why?

12.15 In a not-so-unusual accident, two workers were killed when an employee was cleaning out a tank accessed by a manhole. A second employee saw the first employee collapse. While trying to rescue the first employee, the second employee was also overcome, and both died. What preventive measures can you suggest to prevent accidents of this type?

12.16 What are the two basic types of "safety lenses?" Which is more durable?

12.17 What is the argument against requiring safety glasses and hard hats throughout all areas of the plant, including areas in which they are not needed?

12.18 Name some jobs for which eye protection should be provided.

12.19 Why are "organic vapor respirators" not to be trusted to protect against all organic vapors?

12.20 In an industrial plant, a sign reads "PREVENT ACCIDENTS: WEAR HARD HAT." What principles of personal protective equipment does this sign fail to recognize?

12.21 Why is the provision of personal protective equipment not a very satisfactory solution to the problem of protecting workers?

12.22 What are the hazards of employee-owned personal protective equipment being brought onto the premises at work?

12.23 In what way have undersized manholes for vessel entry resulted in a large number of multiple fatalities in the United States?

12.24 Why must a safety belt for fall protection be much stronger than is required to support the wearer's body weight?

12.25 Name several alternatives to washing piece parts in trichloroethylene by workers placing their bare hands in the solvent.

12.26 Explain the multiple-fatalities hazard associated with entry into confined spaces.

12.27 Describe the principal hazards of confined spaces.

12.28 What is the phenomenon of engulfment? How does death come to the victim?

12.29 Describe the typical hazard mechanism for confined spaces that contain mechanical hazards.

12.30 The safety procedure of inerting is intended to alleviate what hazard? What other hazard does it sometimes create?

12.31 What is the principal hazard associated with oxygen enrichment?

12.32 How do confined spaces impact the definition of *IDLH*?

12.33 Describe some procedures for isolation of a confined space.

12.34 Name one type of commonly encountered dangerous atmosphere for which a gas mask will not help.

12.35 Explain the peculiar aspects of the effects of IDLH exposures to materials such as hydrogen fluoride and cadmium vapors.

12.36 Explain the problems that can develop with a partial program of respiratory protection when respiratory protection is not really required.

12.37 Explain the term *double block and bleed*, that is, what is *blocked* and what is *bled* and why?

12.38 Compare the advantages of demand flow versus continuous flow supplied air respirators.

12.39 Explain the difference between open-circuit and closed-circuit SCBA.

12.40 Identify a problem in maintaining respirators for a toxic gas that is odorless.

12.41 Is it legal for an employer to require a man to shave off his beard to qualify for a job?

12.42 If respiratory equipment is required for the job, is the employer required to pay for it or can the employer require the employee to pay for their own respiratory equipment?

12.43 Are contact lenses considered safe for wearing in the workplace? What is OSHA's position on contact lenses? Do contact lenses have any safety advantages over conventional glasses with frames?

12.44 1910.136 is the standard for protective footwear. Is the standard a specification or performance standard or both?

12.45 The standard on protective footwear incorporates standards from which two standard producing bodies?

12.46 The allowed protection factor for hearing protection, NRR, depends on how the sound is measured. What are the two ways to measure the sound and how do you adjust the NRR for both?

12.47 On an aircraft carrier flight deck, all personnel are required to wear dual hearing protection. The helmet provides an assumed 30 dB of protection while the earplugs provide 25 dB. If a C-weighted dosimeter is used to measure the noise, what total NRR factor can we calculate for protection of personnel?

12.48 Give two reasons why safety shoes are a more expensive undertaking than hard hats.

12.49 Safety shoes have the obvious purpose of protecting the wearer's foot when a heavy load falls on the shoe. However, there is always the possibility that an extremely heavy load can still crush the worker's foot even while wearing safety shoes. For practical purposes, ANSI has specified weight limits for shoes to qualify as "safety shoes." What are these limits?

12.50 Explain how protective gloves can become more dangerous to a worker's hands than no gloves at all.

12.51 Why do safety and health managers often have difficulty seeking a medical physician's advice in selection of first-aid supplies?

12.52 This chapter describes an accident in which three utility workers died while working on a sewer. What special circumstance caused these fatalities?

12.53 Explain the psychology under which a second or even third worker becomes a fatality in a confined space.

12.54 If a space is too small to permit a person to enter, is the space a confined workspace?

12.55 Suppose a workspace has multiple openings for entry and exit. Could it still be determined to be a confined space?

12.56 A 2 ft × 2 ft tank with a 12-square-inch hatch needs to be cleaned by a worker. Does OSHA consider this a "confined space" hazard?

12.57 A workplace is designed for continuous human occupancy but has limited entry and exit. Can it be considered a "confined space?"

12.58 When is it acceptable, when using industrial air compressors for breathing apparatus, to have automatic shutdowns instead of alarms?

12.59 Could a bathroom that has access limited by gender be considered a "confined space" according to OSHA criteria?

RESEARCH EXERCISES

12.60 What is NFPA 101? When was it published?

12.61 Do Internet research to identify OSHA booklet 3138. When was it published?

12.62 Examine the safety of service pits for display waterfalls, such as those seen in shopping malls. Determine whether any accidents or incidents have been reported and what hazards have been found to exist.

12.63 Some workplace environments call for the use of air-supplied suits supplied by either self-contained breathing apparatus units or by supplied air lines. An emergency situation occurs when an "air-off" condition occurs, especially when the worker is still in the dangerous atmosphere. Examine this hazard and determine whether any guidance has been published to deal with it.

12.64 Case Study 12.3 discusses the hazards of entrapment encountered on entering sand bins. Research similar hazards encountered in grain bins. How quickly does a victim, standing in the bin of grain, become trapped when an unloading auger starts at the bottom of the bin? How quickly does the victim become completely immersed in the sinking pile of grain? How much does a 1-foot-deep pile of corn lying on a typical man, 6 feet tall and lying down, weigh (Loewer, 1994)?

12.65 Study the various hazards of methane in confined spaces. How does concentration enter the picture? Compare health and safety aspects.

12.66 NIOSH studied the hazards of confined spaces in the late 1980s, prior to OSHA's promulgation of the confined space standard. How did NIOSH define *confined space*? Identify the three "classes" of confined spaces as seen by NIOSH. What three employer "problems" with respect to confined spaces were identified by NIOSH? What percentage of confined space fatalities consists of "would-be rescuers?"

12.67 What industries did OSHA exempt from coverage under the "permit-required" confined space entry standard? What was the rationale behind these exemptions?

12.68 Find a published estimate of the number of telecommunications manholes in the United States. Are these manholes "confined spaces"? Why or why not? GTE is a major company in this industry. Approximately how many GTE employees enter manholes each year? How many times per year on average do these employees enter manholes? What OSHA standard regulates safe entry into telecommunications manholes?

STANDARDS RESEARCH QUESTIONS

12.69 Study the OSHA General Industry standards to compare enforcement activities surrounding respiratory protection as compared to general personal protective equipment.

12.70 Examine the OSHA General Industry standards for "medical services and first aid." From enforcement statistics for these standards, comment on how seriously OSHA takes this subject. Justify your answer with statistics gleaned from the database on the Companion Website.