Chapter 22

Personal Protective Equipment and First Aid

Objectives

After completing this chapter, you will be able to do the following:

22.1 Describe basic first aid responses. (NAPTA Safety, PPE 1*) p. 358

22.2 Discuss the selection, function, and proper use of personal protective equipment (PPE) in the process industries:

Respiratory protection
Eye protection
Hearing protection
Head protection
Hand protection
Foot protection
Skin protection. (NAPTA Safety, PPE 2, 4) p. 367

22.3 Describe the levels of protection of PPE. (NAPTA Safety, PPE 3) p. 382

22.4 Describe government regulations and industry guidelines that address medical and first aid responses and PPE:

OSHA 1910 Subpart K: Medical and First Aid
OSHA 1910.132–Personal Protective Equipment (PPE)
OSHA 1910.133–PPE: Eye and Face Protection
OSHA 1910.134–PPE: Respiratory Protection
OSHA 1910.138–PPE: Hand Protection. (NAPTA Safety, PPE 5) p. 383

*North American Process Technology Alliance (NAPTA) developed curriculum to ensure that Process Technology courses will produce knowledgeable graduates to become entry-level employees in process technology. Objectives from that curriculum are named here in abbreviated form. For example, "(NAPTA Safety, PPE 1)" means that this chapter's objective relates to objective 1 of the NAPTA curriculum on PPE and first aid.

Key Terms

CPR—cardiopulmonary resuscitation, which is an emergency method to assist a victim whose heart has stopped beating properly, **p. 366.**

First-degree burns—burns that affect only the outer layer of skin and cause pain, redness, and swelling, **p. 362.**

Second-degree burns—burns that affect both the outer and the underlying layer of skin, **p. 362.**

Third-degree burns—burns that affect deeper tissues and cause white or blackened, charred skin that may be numb, **p. 362.**

22.1 Introduction

OSHA requires that employees be given a safe and healthy workplace that is reasonably free of occupational hazards. However, process technicians can be exposed to chemical, biological, physical, and ergonomic hazards inherent to working in a process facility. Although every effort is made to prevent accidents and emergencies, they can still occur on the job, because a process industry work site can pose a variety of potential hazards.

Company policies and procedures determine whether process technicians can provide first aid to victims. Often, an emergency response team (or first responders) and/or a resident medical staff will handle emergencies and accidents, including first aid treatment. At the very least, the process technician must promptly report emergencies and accidents to the proper authorities. Your company will train you on how to report emergency situations and accidents, along with other basic emergency procedures (potentially including first aid training).

Note: This book is not intended to be a first aid or medical guide. Its goal is to inform process technicians of potential emergencies and accidents they might encounter, so they can report useful information to trained first responders or medical staff.

To prevent or minimize hazards, government and the process industries have implemented engineering controls, administrative controls, and the use of personal protective equipment (PPE). Process technicians must understand the proper selection, use, care, and maintenance of PPE. This chapter describes different types of PPE, levels of PPE protection, proper fit and use, and upkeep of PPE.

Potential Injuries and Basic First Aid

In a typical process facility, workers routinely perform tasks that, if not performed safely or properly, might cause injuries. Physical hazards are common; they come from environmental factors such as excessive levels of noise, temperature, pressure, vibration, radiation, electricity, or machinery. This chapter discusses some potential types of injuries that can occur, although the nature and severity of an injury varies due to the hazard agent (the substance, method, or action by which damage can happen to personnel) and site-specific conditions (e.g., work environment, processes, materials, and equipment).

Often, injuries result in minor cuts, pinches, scrapes, bruises, burns, strains, or splinters (Figure 22.1). However, in rare cases more serious injuries can occur. The following are some types of injuries and emergency situations that can occur in the process industries:

- Eye injuries
- Lacerations, punctures, or other causes of bleeding
- Impact injuries (bruises, sprains, or fractures)
- Back injuries

- Burns
- Head injuries
- Electric shocks
- Breathing problems
- Injuries from contact with chemical or biological substances

Figure 22.1 Every facility has materials for first aid. Some of the most common injuries in the process industries include cuts, pinches, scrapes, bruises, burns, strains, or splinters.

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Regardless of the type of injury that you or a fellow worker sustain, you must follow your facility's procedures for obtaining trained help and reporting the injury. (OSHA requires certain types of injuries to be recorded.) Following are some general recommendations for dealing with injuries in the workplace:

- Report the situation immediately to the proper authorities, as outlined in your company's policies and procedures. Provide as much accurate information as possible about the location, situation, and victim's status and symptoms.
- Make sure the scene is safe. Do not rush to help if doing so would put you or someone else in danger (e.g., live electric wires in contact with the victim).
- If properly trained and company policies and procedures permit, administer first aid.
- Do not move a victim unless a critical situation threatens the victim (e.g., fire, threat of explosion, hazardous atmosphere).
- Remember to use proper PPE and follow safety procedures while dealing with the situation, so you do not become a victim also.
- Remain calm and observant.
- Provide a full and accurate report on the situation and/or assist with any investigation.

The following are general descriptions of each type of injury. To learn more about these injuries and their treatment, check with your employer about available first aid courses. The American Red Cross and National Safety Council also offer courses to the public. For additional training, you can enroll in an emergency medical technician (EMT) or paramedic program.

Eye Injuries

Eye injuries can occur when a foreign object or substance comes into contact with the eye. Flying particles or falling objects, such as chips, metal shavings, dust, and other similar hazards are common causes of injury, according to the Bureau of Labor Statistics. Often, these objects are tiny and are moving fast (e.g., being thrown by a moving equipment part). Sparks (e.g., from tasks such as welding and grinding) can also strike the eye and cause damage.

Contact with chemicals and other hazardous substances (e.g., molten metal, biological agents) is another common cause of eye injuries. Other accidents are caused by swinging objects (e.g., ropes, chains) that strike the eye.

The eyes can be protected from injury using PPE such as safety glasses, safety goggles, or face shields (Figure 22.2). Eyewash stations (like drinking fountains, but with two streams) can be used to help with eye injuries. See the PPE section in this chapter for details.

Figure 22.2 Safety glasses, safety goggles, and face shields protect the eyes from injury caused by flying debris.

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Injuries That Cause Bleeding

Most bleeding occurs from minor cuts, scrapes, punctures, or gashes (Figure 22.3). Bleeding can be mild or severe. The hands are a common place for injuries to occur. If you step on a sharp object, your foot can be punctured. Thrown or falling objects can cause impact injuries (bruises, fractures), sometimes accompanied by bleeding. Severe cuts (such as to an artery) can cause a victim to bleed profusely, pass out, and even die.

Figure 22.3 Most bleeding occurs from minor cuts, scrapes, punctures, or gashes that can be treated with first aid equipment.

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A variety of hazards in the process industries can cause injuries that bleed: using tools, coming into contact with moving equipment parts, getting hit by a thrown or fallen object, or getting a body part caught between two hard surfaces.

The hands can be protected from injury by using gloves. Feet can be protected by wearing safety footwear. Other body parts can be protected by other types of PPE. See the PPE section in this chapter for details.

Impact Injuries

Impact can occur in a variety of ways. The worker may be hit by thrown or falling objects. A worker might drop materials he or she is carrying (e.g., pipes, drums, and bags). Workers

can slip or trip or fall from a height. Workers might also be involved in a vehicle accident. Impact can result in injuries such as the following:

- Bruises
- Bleeding
- Strains
- Fractures
- In extreme cases, death

Even a short fall of 3 to 4 feet (1–1.3 m) can cause a major injury or even death. Also, if a person is working at heights and using fall protection, a fall can still cause impact injuries (e.g., from the harness violently jerking against a body part) (Figure 22.4).

Figure 22.4 **A.** Safety harness. **B.** Process technicians should always wear proper PPE when working at heights.
CREDIT: A. Paulo Vilela/Shutterstock. **B.** Alessia Pierdomenico/Shutterstock.

A.

B.

OSHA requires workers to be trained and wear fall protection in most cases when working at a height of 4 feet (1.3 m) or more unless handrails or similar barriers are present. Your employer will provide and train you in proper use of fall protection equipment.

Various PPE can be used to protect workers against impact injuries. Such PPE include hard hats, gloves, safety shoes, fall protection, and safety glasses, goggles, or face shields. See the PPE section in this chapter for details.

Back Injuries

Back injuries can range from minor to serious. Some require rest and other simple treatments, while severe ones can result in surgery, permanent disability, or death. Back injuries can occur in any situation, whether the work environment is a process unit or an office environment. They are not always caused by lifting heavy objects or performing laborious tasks; even something as simple as bending over to pick up a dropped object can cause an injury (Figure 22.5).

INCORRECT LIFTING CORRECT LIFTING

Figure 22.5 Many back injuries occur as a result of improper lifting technique.

CREDIT: (*left*) PHOVOIR/Alamy Stock Photo. (*right*) Hero Images Inc./Alamy Stock Photo.

The following are some situations that can potentially result in a back injury:

- Lifting or handling materials incorrectly
- Using tools improperly
- Slips, trips, and falls
- Falling from heights
- Impact (e.g., falling objects, getting caught between two hard surfaces)
- Twisting the body in an unnatural position
- Vehicle accidents
- Bending over

Although a back belt can be used, following proper ergonomic practices is the better approach to prevent or minimize a back injury. See Chapter 15, *Recognizing Ergonomic Hazards* for more details. Check your company's policy on the use of back belts. Proper footwear can help prevent slips and falls, while fall protection can minimize injuries due to falls from heights.

First-degree burns burns that affect only the outer layer of skin and cause pain, redness, and swelling.

Second-degree burns burns that affect both the outer and the underlying layer of skin.

Third-degree burns burns that affect deeper tissues and cause white or blackened, charred skin that may be numb.

Burns

There are three levels of burns. A **first-degree burn** affects only the outer layer of skin and causes pain, redness, and swelling. A **second-degree burn** affects both the outer and the underlying layer of skin. These burns cause pain, redness, swelling, and blistering. A **third-degree burn** affects deeper tissues and causes white or blackened, charred skin that may be numb (Figure 22.6).

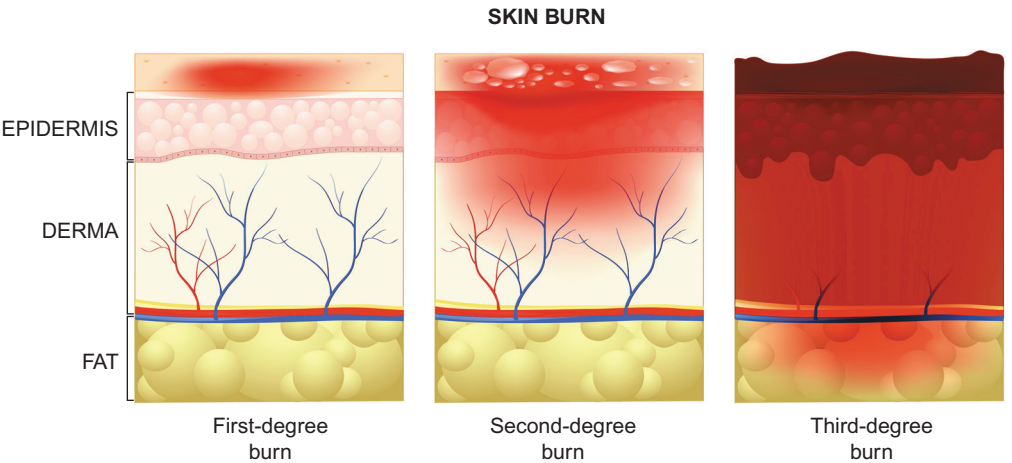

Figure 22.6 There are three levels of burns.

CREDIT: Designua/Shutterstock.

Burns can be caused by fire, hot steam or liquids, radiation, friction, heated objects, the sun, electricity, or chemicals. Thermal burns are the most common type of burn in the process industries. They occur when hot metals, liquids, steam, or flames come in contact with the skin. Because there is a large amount of hot piping and steam release within a plant, thermal burns occur frequently.

Various types of PPE can be used to prevent or minimize the hazards of burns, such as the following:

- Flame resistant clothing (FRC)
- Specially cooled clothing
- Gloves
- Safety footwear
- Helmets or masks
- Tinted face shields, safety goggles, or safety glasses
- Protective (barrier) creams

Respiratory protection can provide a barrier against flame related hazards such as smoke or vapor. See the PPE section in this chapter for details.

Head Injuries

Head injuries can occur in the plant due to situations such as the following:

- Impact (e.g., thrown or falling objects, getting caught between two hard surfaces)
- Slipping or tripping
- Falling from a height
- A vehicle accident

Head injuries can be minor or major, but even a minor head injury can result in a more severe condition, such as concussion, blackout, or disorientation. Major head injuries can result in permanent disability or death. Head injuries can also include neck or spine injuries. All head injuries should be considered as major until a professional medical person can provide diagnosis and treatment. The most common type of PPE to prevent or minimize head injuries is the hard hat. See the PPE section in this chapter for details.

Electrical Shocks

Electrical hazards can result from situations such as the following:

- Improper wiring or grounding
- Short circuits (Figure 22.7)

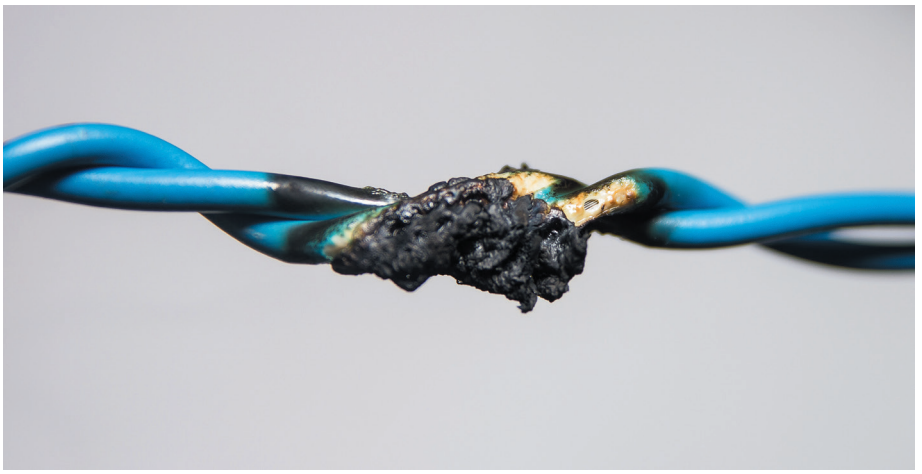

Figure 22.7 Electrical shorts can produce fire and electrical shock hazards.

CREDIT: Markik/Shutterstock.

- Cracked, degraded, or wet insulation
- Surges and overloads
- Equipment failure
- Static electricity buildup
- Downed power lines
- Lightning strikes

An electrical shock occurs when a person is exposed to electric current. Electrical shock and other electrical hazards occur when a person contacts a conductor carrying electricity while also touching the ground or an object that has a conductive path to the ground. The person completes the circuit as the current passes through his or her body. Following are some symptoms of electrical shock:

- Unconsciousness
- Cessation of breathing
- Weakness
- Weak or absent pulse
- Stopped heart
- Burned skin
- Stiffness of muscles in the body

Besides burns, electrical shock can cause muscle damage, ventricular fibrillation (rapid, irregular contractions of the heart), cardiac arrest, cessation of breathing, and death. If you see a victim of an electrical shock, DO NOT touch the victim. Make sure the power source is turned off immediately. DO **NOT** use wood, tree limbs, or plastic to push, pull, or roll the victim away from the source of electricity. The moisture in the material can conduct electricity and electrocute the rescuer. High voltage can arc or jump up to three feet (about a meter) through the air, so make sure the power is off before attempting to help. PPE can prevent or minimize the hazard of electrical shocks:

- Hard hats
- Insulated gloves
- Safety footwear (nonconductive)

See the PPE section in this chapter for details.

Breathing Problems

Breathing problems can result from a variety of causes, including exposure to hazardous chemicals in the atmosphere, air pollution, allergens, extreme temperatures, pressure changes, and overexertion.

Breathing troubles can result in the following conditions:

- Coughing and wheezing
- Sneezing
- Shortness of breath or gasping
- Gagging
- Vomiting
- Loss of consciousness
- Turning blue (a condition called cyanosis)
- Death

The following are some hazardous atmospheres the process technician might encounter:

- Smoke
- Airborne substances or chemicals (toxic or nontoxic)
- Oxygen-deficient environment
- Oxygen-enriched environment

Respiratory protection can provide a barrier between a worker and hazardous atmospheres or supply air at the correct oxygen level (Figure 22.8).

Figure 22.8 Respiratory protection can provide a barrier between a worker and hazardous atmospheres.

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Contact with Chemical or Biological Substances

Workers handling chemicals and/or biological substances can come into contact with these substances. The effects will vary, based on factors such as the type of substance, the amount of the substance, the type of exposure (e.g., inhalation, absorption), and the length of exposure. See Chapter 3, *Recognizing Chemical Hazards* and Chapter 4, *Recognizing Biological Hazards* for more details.

Various types of PPE can be used to prevent or minimize exposure to these substances:

- Chemical suits, biohazard suits, or similar clothing and gear
- Respiratory protection
- Hard hats
- Gloves
- Safety footwear
- Face shields, safety goggles, or safety glasses

Eyewash stations can be used to remove any chemical or biological substances in or near the eyes, while safety (deluge) showers can be used to remove such substances from the body.

See the PPE section in this chapter for details.

Other Injuries

The following are some other potential injuries and emergency situations:

- Cessation of breathing
- Stopped heartbeat
- Shock
- Choking

CPR cardiopulmonary resuscitation, which is an emergency method to assist a victim whose heart has stopped beating properly.

Trained personnel can administer **CPR** (cardiopulmonary resuscitation) to victims who have stopped breathing and/or have no heartbeat. Administering CPR properly and promptly can make the difference between life and death. You can become CPR-certified through your company's program or other outside agency (e.g., Red Cross).

Shock is different from an electrical shock. This life-threatening medical emergency results in bodily collapse or near collapse that comes from an inadequate delivery of oxygen to the body's systems. Shock victims require immediate medical attention, or permanent disability or death can happen. Always be alert for signs of shock when dealing with any injury. Shock can appear in a variety of ways:

- Weakness
- Pale, cold, and/or clammy skin
- Cyanosis (turning blue)
- Chills
- Vomiting
- Shallow or rapid breathing
- Change in body temperature (high or low)
- Change in heart rate (fast or slow)
- Chest pain
- Restlessness
- Personality change
- Mental confusion
- Coma

Choking is caused by food or an object blocking a person's upper airway, which prevents proper breathing. A first aid technique called the abdominal thrust or Heimlich maneuver (Figure 22.9) can be performed on a choking victim to dislodge the trapped object from the airway.

Figure 22.9 Abdominal thrusts (Heimlich maneuver) can be performed on a choking victim to dislodge a trapped object from the airway.

CREDIT: SpeedKingz/Shutterstock.

Choking signs include the following:

- Inability to talk
- Clutching the throat with one or both hands (this is the universal choking sign)
- Wheezing or coughing
- Panic

- Wild gestures
- Turning blue
- Loss of consciousness

As stated previously, usually only trained personnel should attempt any first aid treatment, including CPR or the Heimlich maneuver. CPR and first aid skills should be updated regularly because treatment methods change, and technology provides better ways to help people (e.g., automatic external defibrillators, or AED). There is a new technique for the untrained rescuer, however. It is known as "compression only CPR." It can be used if there is no one available who knows proper first aid and if trained responders are delayed. Push forcefully down on the nonbreathing victim's chest in the center of the breastbone and compress the chest 2 to 2.4 inches (5-6 cm) deep. Compressions should be done at a rate of 100 to 120 pumps per minute. This can be very frightening to the person performing the rescue, but taking action could save a life. Irreversible brain damage and death can result from doing nothing when a person's brain is deprived of oxygen.

22.2 Personal Protective Equipment

Personal protective equipment (PPE) is specialized clothing and equipment worn or used by workers to minimize the risk of injury from exposure to various hazards in the workplace, including chemical, physical, biological, and ergonomic hazards. In industry there are situations in which engineering controls (technological and engineering improvements used to isolate, lessen, or remove a hazard) and administrative controls (e.g., policies, procedures, and activities) do not effectively reduce the worker's exposure down to acceptable levels. In these situations, OSHA regulations require use of personal protective equipment to reduce employee's exposure to hazards. PPE is considered the last line of defense against workplace hazards (see Figure 22.10).

Figure 22.10 Personal protective equipment minimizes the risk of injury from exposure to various hazards in the workplace.

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The following are different types of PPE that may be provided to the process technician:

- Respiratory protection: air-supplying respirators and air-purifying respirators
- Hearing protection: earmuffs, disposable earplugs, reusable molded earplugs, helmets
- Eye protection: safety glasses, safety goggles, face shields
- Face protection: face shields, helmets, masks

- Head protection: hard hats, bump caps
- Body and skin protection: chemical suits, flame resistant clothing, aprons, slickers
- Hand protection: chemical- and liquid-resistant gloves, leather or canvas gloves, insulated gloves
- Foot protection: safety shoes or boots, rubber boots, nonconductive footwear

Two main groups are responsible for promoting standards that PPE must meet to provide proper protection:

- The National Institute for Occupational Safety and Health (NIOSH) is a government agency that carries out research and training and recommends new standards and criteria to OSHA. NIOSH standards are used for respirators.
- The American National Standards Institute (ANSI) is an organization that develops and promotes standards in a wide variety of areas, including PPE.

OSHA requires that many categories of PPE meet or be equivalent to ANSI standards:

- **Eye and Face Protection**—ANSI Z87.1-1989
- **Head Protection**—ANSI Z89.1-1986
- **Foot Protection**—ANSI Z89.1-1991

No ANSI standards are available for hand protection, so gloves should be selected based on the task to be performed and the glove's performance and construction characteristics.

When PPE is required, a PPE program should be implemented according to OSHA. (See Chapter 3, *Recognizing Chemical Hazards* and Chapter 4, *Recognizing Biological Hazards*.) The PPE program should cover the following:

- Hazards present
- Selection, maintenance, and use of PPE
- Training of employees
- Monitoring of the program to ensure its ongoing effectiveness

Employers perform a hazard assessment, evaluating potential hazards in the facility based on basic categories such impact, penetration, compression, chemical hazards, heat or cold, presence of harmful dust, light (optical) radiation, or biological hazards. The following hazards are surveyed during the assessment:

- Electricity sources
- Motion sources
- High-temperature sources
- Radiation sources
- Harmful dust sources
- Types of chemicals used or present
- Types of biological materials used or present
- Sharp objects
- The potential for falling or dropped objects

Based on this assessment, employers determine the proper types of PPE required. OSHA recommends that employers provide a level of protection greater than the minimum required.

Companies provide PPE to workers, along with training on how to select, fit, use, and maintain it. If a company does not provide certain types of PPE, they can reimburse the employee for purchasing the appropriate items on their own (e.g., safety shoes, prescription eye protection).

Proper Use and Care of PPE

OSHA mandates that employers check that workers demonstrate an understanding of PPE training, along with the ability to properly wear and use the PPE. This must be done before workers perform the task that requires the PPE.

The following are some general expectations of process technicians relating to PPE:

- Know when PPE is necessary.
- Select the proper PPE.
- Understand the limitations of PPE.
- Inspect PPE before use and make sure it fits.
- Use PPE properly, especially when using multiple types of PPE together.
- Take off PPE when done, and then inspect it again.
- Clean, maintain, and store the PPE.
- Report damaged PPE and replace it.

A wide range of PPE types, many of which are described in this chapter, are used to protect process technicians from head to toe in a variety of situations and hazards. Because the types of PPE vary and there are numerous PPE manufacturers, it is outside the scope of this textbook to cover all possible PPE information.

OSHA regulations require employers to supply different types of PPE to workers. They must then train workers on hazards, along with proper PPE selection, limitations, fit, use, care, and maintenance. Process technicians must receive this training when they first join a company and periodically throughout their employment.

This section will provide only general tips related to PPE:

- Understand the hazards in your workplace, including chemical, physical, biological, and ergonomic. Consider the relationship hazards have with each other (e.g., fire hazards with chemical hazards, hot weather with fired equipment). Hazards can change based on materials used, equipment maintenance, new processes, environmental conditions, or other factors. Keep updated on these hazards.
- Know what effects hazards can cause, and how they relate to you, your coworkers, the facility, the local community, and the environment. For example, understand what chemicals cause cancer, damage skin, or produce respiratory troubles.
- Follow all government regulations, company policies and procedures, and unit-specific requirements relating to safety, health, and the environment. Read and follow documentation, safety data sheets (SDSs), labels, signs, and other important information. Also, remember that common sense is a good tool for all workers when it comes to safety.
- Choose the right PPE. Make sure it fits properly and comfortably. PPE must be used correctly and continuously to be effective. For example, if you remove hearing protection for even a moment, you can be exposed to damaging high noise levels. When finished using PPE, make sure to inspect it for damage and repair or replace it as necessary. Thoroughly clean PPE following manufacturer's recommendations and company procedures. Then, store PPE so it is ready for its next use.
- Practice good personal hygiene (e.g., wash hands, shower, keep ears free of wax) and grooming (no beard, long hair secured). Proper diet, exercise, and rest are vital also, along with periodic medical examinations (e.g., health, vision, and hearing). Make sure you are up to date on all vaccines (e.g., tetanus).

FIT AND COMFORT Workers are more likely to properly wear PPE that fits well and is comfortable. Properly fitting PPE can mean the difference between being protected or exposed. Make sure you select the proper-size PPE.

Once PPE has been selected, remember the 3 Cs:

- **Correct**—adjust the PPE so it fits properly.
- **Comfortable**—make sure the PPE is comfortable and does not significantly hamper normal motions.
- **Compulsory**—make sure you wear the PPE at all times during hazard exposure.

Often, multiple pieces of PPE are worn together. For example, a process technician might need to wear earmuffs, a hard hat, safety goggles, gloves, safety footwear, and other PPE to perform a task. Make sure that the PPE is compatible and does not cause problems when worn together. All PPE must be adjusted to fit together, so that protection is not reduced or compromised in any way. Once all PPE is adjusted, practice some common motions of work tasks (e.g., squatting, lifting an arm, and walking) to get the feel of the PPE and see if any additional adjustments are required.

LIMITATIONS It is crucial that process technicians understand not just the protection, but also the limitations. Companies will provide training on specific limitations, but the following is a general list:

- PPE can take time to put on correctly. This can be critical in emergency situations. The process technician must understand how to put on and take off PPE quickly, especially respirators. In fact, donning a respirator should be practiced.
- Wearing PPE can limit mobility and hinder the wearer, especially if multiple pieces are worn at the same time. Gloves can reduce dexterity, full-face respirators can limit vision, and full chemical suits can reduce arm and leg motion.
- Communications (speech and hearing) can be impaired when wearing a respirator or hearing protection.
- The likelihood of heat stress increases when wearing PPE. Some body protective suits do not "breathe" so heat and sweat is trapped inside the suit.
- PPE adds to the total weight of the wearer, making normal tasks harder and resulting in increased exertion.
- Some PPE is limited in its use. The wearer can only be exposed to a hazard for a certain amount of time before the risk of exposure increases (e.g., respirators with filters).
- PPE can be constrictive and cause the wearer psychological stress, especially in situations such as confined space entry or working at heights.
- Improper fit and use can lead to exposure.
- The wearer can experience a feeling of overconfidence that results in lax safety habits or not following safety procedures.

PPE can lose its effectiveness due to the following factors:

- **Penetration**—hazardous materials pass through the PPE barrier, due to an opening caused by a tear, PPE slippage, incorrect fit, or some other factor.
- **Permeation**—hazardous material crosses through the PPE barrier. This depends on the properties of the PPE, the nature of the hazard, and duration of exposure.
- **Degradation**—hazardous material or other forces (sunlight, heat, and moisture) break down the PPE properties through contact over time.
- **Contamination**—the wearer is exposed to hazardous materials and the PPE is not thoroughly cleaned.

Types of PPE

The following is an illustration of different types of PPE, followed by specific descriptions of each type.

RESPIRATORY PROTECTION Respirators protect workers from exposure to hazardous atmospheres that can result in acute or chronic health hazards. Respirators fall into one of the following two types:

- **Air supplying**—provides breathable air to the wearer through a mask and hose connected to a clean air source (Figure 22.11). Examples include an air line, hose mask, self-contained breathing apparatus (SCBA).
- **Air purifying**—filters contaminants out of the air or neutralizes chemicals, protecting the wearer from particles as small as 0.3 microns. They cannot be used in oxygen-deficient atmospheres, those with less than 19.5 percent oxygen (O_2) content. Examples include a dust mask, half or full face mask, gas mask.

If you wear prescription glasses or contacts, check with your company about the impact these have on respirator use. Special adjustments might need to be made for full-face respirators (e.g., SCBA masks, air line masks). See Chapter 8, *Hazardous Atmospheres and Respiratory Hazards* for details on respirator descriptions, selection, fit, use, and care.

Figure 22.11 Air-supplying respirators provide breathable air to the wearer through a mask and hose connected to a clean air source.

CREDIT: Nikitin Victor/Shutterstock.

HEARING PROTECTION Hearing protection is used when excessive noise is present in the workplace. Following are factors that determine excessive noise:

- Loudness of the sound (in dB)
- Duration of worker's exposure
- Whether the noise is generated by one or multiple sources
- If the worker moves between work areas with different noise levels

Hearing protection only reduces the amount of noise that reaches the ears; it does not eliminate it entirely. Hearing protection has an associated noise reduction rating (NRR).

The main types of hearing protection are earplugs and earmuffs:

Earplugs–made of materials such as foam, rubber, waxed cotton, fiberglass wool, or plastic, and inserted into the ear canal. Some types are preformed or molded (fitted for a specific individual by a professional) while other types are self-forming (i.e., they expand in the ear). Earplugs can be reusable or single-use.

Earmuffs–cover the entire ear with a cushioned cup held in place with a headband.

Earplugs and earmuffs can reduce noise levels by up to 20–30 dBA. Earmuffs generally have a higher noise reduction rating than earplugs. Worn together, they can reduce the noise level up to an additional 5 dBA. (This is required if the worker is exposed to noise levels of 110 dBA or higher.)

Did You Know?

Noise-induced hearing loss (NIHL) can be caused by a single loud impulse noise (e.g., an explosion) or by loud, continuous noise over time (e.g., noise generated in a woodworking shop). Hearing protection should always be worn when working in environments with sounds louder than 80 dB (normal conversation is around 60 dB). Other sounds that can cause NIHL include motorcycles, firecrackers, and firearms, all of which range from 120 to 140 dB.

CREDIT: Loco/Shutterstock.

In some cases, special helmets must be used that dampen (reduce) noise and protect against vibrations. Some helmets also provide head protection, like a hard hat. These vary by the type of hearing hazard and work situation.

Hearing protection is selected based on the following criteria, in order of importance:

1. Intensity of noise
2. Personal comfort
3. Availability

Fingers or cotton do not provide adequate protection against noise. Use proper hearing protection.

Earplugs must be inserted properly in the ear canal to be effective. Consult your company's procedures and/or manufacturer's instructions to ensure a good fit. Clean reusable earplugs regularly, based on the manufacturer's recommendations. Replace earplugs if they cannot be thoroughly cleaned. Dispose of single-use earplugs after use.

Make sure earmuffs fit snugly over your ears and form a perfect seal. Clean them thoroughly after use. Glasses, long hair, and facial movements (e.g., yawning or chewing) can reduce the protective value of earmuffs. See Chapter 10, *Hearing and Noise Hazards* for more details.

EYE PROTECTION Eye protection (see Figure 22.2) is PPE that reduces the risk of hazards to the eyes from the following:

- Flying objects (e.g., metal chips, dust)
- Falling objects
- Extreme temperatures
- Chemical splashes (e.g., corrosive liquids)
- Irritating mists
- Hot fluid splashes (e.g., steam, molten metals)
- Glare
- Sparks
- Radiation burns

Eye protection PPE comes in a variety of types, based on the hazard:

- **Safety glasses**—protective eyewear with metal or plastic frames and impact-resistant lenses. They are more shatter resistant than normal eyewear. They can come with or without side shields.
- **Safety goggles**—tight-fitting protective eyewear that completely cover the eyes, eye sockets, and face around the eyes. They protect your eyes from the front and sides against impact, dust, and splashes.
- **Face shields**—a sheet of transparent plastic attached to a headband, which extends from the eyebrows to below the chin and across the width of the face. Face shields protect the face and front of the neck from flying particles, dust, sprays, or splashes. They do not protect against impact. They can be worn with safety goggles or safety glasses to provide extra protection. They can be clear or polarized (tinted) for glare protection.
- **Helmets and masks (e.g., welding shields)**—these types of eye protection vary based on the specific hazard.

Other types of specialized eye protection are available, depending on the hazard (radiation, laser light, and UV light). Your company will provide these.

All eye protection must meet or be equivalent to the ANSI standard (ANSI Z87.1-1989). Eye protection should allow for air to circulate between the eye and the lens, and fit properly. Your company can help you select the proper eye protection for the work situation. You must understand how to use it, along with when and where to use it.

For people who wear corrective eyewear (prescription glasses or contacts), eye protection should either include the prescription in the design or properly fit and not interfere with the prescription glasses or contacts (i.e., the worker's vision must not be inhibited or limited). Eyeglasses are never a substitute for proper eye protection. Contacts present a hazard in that they can trap a hazardous substance (e.g., chemical, metal shaving, and dust) between the wearer's eye and the lens. Some companies have policies specifying where tinted-lens glasses and/or sunglasses cannot be worn (e.g., indoors or in dimly lit areas).

The following are some tips for using and maintaining eye protection:

- Follow company guidelines and manufacturer's recommendations for cleaning eye protection.
- When cleaning eye protection, never use harsh abrasives that could scratch the lenses or remove any protective coatings.
- In cases where workers must share eye protection, it must be disinfected after each use.
- Prescription eye protection should not be shared.

In case of accidental exposure to a hazard, eyewash stations are located around the facility. Process technicians should know where the closest eyewash station is to their work area.

FACE PROTECTION Face protection is used to reduce hazards to the face (including the head and neck), such as impact, chemical or hot metal splashes, heat, radiation, and other hazards.

Some typical types of face protection include the following:

- **Face shields**—protect the face and eyes from flying particles, dust, sprays, or splashes. They do not protect against impact (Figure 22.12).
- **Acid proof hoods**—protect the head, face, and neck against splashes from corrosive chemicals.
- **Welding helmets**—protect against splashes of molten metal and radiation burns.

Figure 22.12 Face shields protect the face and eyes from flying particles, dust, sprays, or splashes, but do not protect against impact.

CREDIT: Reggie Lavoie/Shutterstock.

HEAD PROTECTION Head protection is used to protect against the following hazards:

- Impacts from falling objects or fixed objects (e.g., low-hanging beams or equipment such as pipes)
- Penetration
- Electrical shock
- Burn hazards

Hard hats must be impact resistant and meet the ANSI standard (ANSI Z89.1-1986) for protective headwear (Figure 22.13). A hard hat consists of a hard outer shell and a web lining suspension system that absorbs and spreads the shock of an impact. Most hard hats have a bill across the front, but some have a brim all around it, similar to a traditional safari helmet.

Figure 22.13 Hard hats must be impact resistant and meet the ANSI standard for protective headwear.

CREDIT: Gorodenkoff/Shutterstock.

Hard hats fall into one of the following three categories:

- **Class A**—provides impact and penetration resistance along with limited voltage protection (up to 2,200 volts).
- **Class B**—provides the highest level of protection against electrical hazards, with high voltage shock and burn protection (up to 20,000 volts); this type also provides protection from impact and penetration hazards by flying or falling objects.
- **Class C**—provides lightweight comfort and impact and penetration protection, but does not protect against electrical hazards.

The following are some tips for properly using and maintaining a hard hat.

- Never modify the hard hat (e.g., add stickers, paint it, drill holes, or remove webbing).
- Make sure it is adjusted to fit on your head properly (refer to the manufacturer instructions with the hard hat):
  - Adjust the headband to fit your head, while still allowing sufficient space between the outer shell and the web lining.
  - The hat should not bind, fall off, or irritate the skin.
- Wear your hard hat with the bill turned to the front (do not place it on your head backward).
- If you have long hair, secure it tightly under the hard hat.
- Follow the manufacturer's recommendations for cleaning. Some cleaning materials might damage the shell and/or reduce electrical resistance.
- Store the hard hat out of direct sunlight and heat, which can weaken the shell.
- Replace the liner regularly (about once a year).
- Inspect the hard hat daily. Replace it when any of the following occur:
  - You notice any cracks, holes, breaks, flaking, scratches, brittle spots, discoloration, or loss of gloss.
  - It receives a significant impact.
  - The date stamp has expired (hard hat material can age and lose its integrity, especially if exposed to harsh conditions frequently).

Some hard hats are designed for use with other PPE or optional accessories, such as earmuffs, safety glasses, face shields, and mounted lights. Accessories should not compromise the safety elements of the hard hat.

Another type of protective headwear is called a bump hat or cap. These do not meet ANSI standards, and are intended only to protect against bumping into an obstruction and not against impact (e.g., a falling object).

BODY AND SKIN PROTECTION In some situations, workers must shield most or all of their bodies against hazards in the workplace such as exposure to the following:

- Chemicals
- Hot metals
- Hot liquids
- Biological hazards
- Radiation
- Hazardous material or waste
- Impacts
- Cuts, abrasions

Body and skin protection is used chiefly to protect most of the body (e.g., torso) or all of it, including the arms, legs, and head. Skin provides a large surface area for chemicals to penetrate or attack, so protecting it is vital. The torso includes major organs, including the heart, lungs, kidneys, liver, and intestines, all of which must be protected from chemical and biological hazards. Chemical hazards can come from a solid, liquid, or gas element, compound, or mixture; biological hazards come from living or once-living organisms, such as viruses, mosquitoes, or snakes.

Various materials are used to create body protection, including fire retardant wool and cotton, plastic, rubber, leather, neoprene synthetics, paper-like fiber (typically for disposable items) and other materials. Body and skin protection comes in various forms, depending on the hazard:

- **Chemical protective suit**—protects the wearer from hazardous chemical spills and splashes. Multiple layers of different materials can be used to increase the level of protection. These suits do not protect against all types of chemicals; the type of chemical hazard will determine the type of chemical suit to use. They do not protect against heat and flames. Chemical hats, hoods, gloves, and boot covers can be added to provide full protection. Sometimes, tape is used to seal potential entry points (e.g., sleeves, cuffs).
- **Totally encapsulating chemical protective (TECP) suit**—provides the highest level of protection from hazardous chemicals (e.g., spills, splashes, vapor), covering the wearer from head to toe (full body suit); this suit is airtight and used with an air-supplying respirator. There are various types available for specific chemicals and situations. A similar type of suit, commonly called a biohazard suit, protects against biological hazards. Another type shields against radioactivity.
- **Aprons and smocks**—protect a major portion of the wearer against chemical splashes and spills; gloves, face shield and goggles, boots, respirator, and other PPE can be added to improve protection.
- **Flame resistant clothing (FRC)**—protects the wearer for a limited time against flames or heat (Figure 22.14). It can also protect against sparks and bursts of electric arcs. These types of garments use specially treated materials to provide protection that will resist bursting into flames for a brief period of exposure. FRC does not protect against lengthy exposure to flames or heat. It also does not provide protection from chemical exposure.

Figure 22.14 Flame resistant clothing (FRC) helps protect the wearer against flames and heat.

CREDIT: Andrey_Popov/Shutterstock.

- **Slickers**—protect workers from wet conditions; they consist of separate pants and a jacket that can be worn over another garment. Slickers are typically not fire resistant. They can provide limited protection against certain types of chemicals.

- **Reflective clothing**—protects against radiant heat. See the Special Types of PPE section of this chapter for more details on temperature extremes.
- **Barrier creams**—provide skin protection from irritants; they are also called protective ointments. They can be used in cases where gloves or other hand and arm protection cannot be safely or effectively used. Some barrier creams (similar to sunscreen) can be used to protect against certain heat or light exposure. Typically, they must be reapplied periodically during a shift. Check with your company about barrier cream use. When conditions allow for proper PPE use, barrier creams cannot be used as a substitute.

Other types of body and skin protection can be used in various forms (e.g., lab coats, vests, jackets, coveralls, and full body suits). Your company will provide this PPE as the hazard or situation requires.

HAND AND ARM PROTECTION For protection against chemicals, glove selection must take into account the chemicals encountered, the chemical resistance, and the physical properties of the glove material.

Hand and arm protection is used to protect against hazards (Figure 22.15) such as the following:

Figure 22.15 Gloves help protect the hands from injury and exposure to hazardous substances.

CREDIT: Voronina Svetlana/Shutterstock.

- Chemical exposure
- Cuts, abrasions, and scratches
- Impact (fractures, bruises, strains)
- Penetration and punctures
- Burns (chemical or temperature)
- Hot or cold temperatures
- Electrical shock

Hand and arm protection comes in a variety of types:

- Gloves (extending to the wrists, mid-arm, or elbow)
- Hand pads
- Finger guards
- Wristlets
- Arm coverings or sleeves

To select the proper hand and arm protection, consider the following factors:

- Hazards present (chemical, physical, biological, ergonomic)
- Specific work activities planned
- Body part requiring protection (hand only, forearm, arm)

- Grip requirements (dry, wet, oily conditions)
- Duration of contact with the hazard
- Glove performance characteristics
- Size and comfort

OSHA lists four broad categories of protective gloves:

- Leather, canvas, or metal mesh
- Fabric or coated fabric
- Chemical and liquid resistant
- Insulating rubber gloves

This section focuses on gloves, the primary type of hand and arm protection.

Leather, canvas, or metal mesh materials are used to create sturdy gloves that provide protection against physical hazards, (e.g., punctures, cuts, abrasions, and burns). Leather or canvas gloves also provide protection against sustained heat, sparks, and blows. Metal mesh protects against knives and sharp objects. You should not use any of these types of gloves when working with chemicals.

Fabric and coated fabric gloves are made of cotton or other fabrics. Fabric gloves protect against dirt, chafing, abrasions, and slivers. They do not work well with rough or sharp materials, or heavy materials. Coated fabric gloves typically combine cotton and plastic, which provide some hand protection and offer slip resistant qualities.

For chemical and liquid protection, select hand and arm protection based on the chemicals or liquids to be handled, the nature of the contact (e.g., splash, immersion), and duration of exposure. Consult company information (e.g., a safety data sheet and manufacturer's recommendations) for proper selection. The Department of Energy rates various protective gloves for their effectiveness against specific chemicals in its Occupational Safety and Health Technical Reference manual.

Chemical- and liquid-resistant gloves can be made of materials such as neoprene, butyl, nitrile, latex, plastic, or combinations of materials. The following are descriptions of various glove materials and their properties:

- **Neoprene**—synthetic rubber gloves provide good flexibility and permit dexterity, are high density and tear resistant. OSHA states that neoprene can protect against alcohols, organic acids, alkalis, gasoline, and hydraulic fluids. The chemical and wear-resistance properties are better than natural rubber.
- **Butyl**—synthetic rubber gloves remain flexible at low temperatures and resist oxidation, ozone corrosion, and abrasion. OSHA states that butyl protects against peroxide, rocket fuels, highly corrosive acids (nitric acid, sulfuric acid, hydrofluoric acid, and red fuming nitric acid), strong bases, alcohols, aldehydes, ketones, esters, and nitro compounds. Butyl is not recommended for use with aliphatic and aromatic hydrocarbons and halogenated solvents.
- **Latex**—natural rubber gloves are comfortable to wear, elastic, somewhat temperature resistant, and stretch well without breaking (tensile strength), can protect against abrasive tasks (e.g., grinding). OSHA states that latex protects against most water solutions of acids, alkalis, salts, and ketones. However, latex gloves can cause allergic reactions (see Chapter 4, *Recognizing Biological Hazards*). For this reason, hypoallergenic gloves, glove liners, and powderless gloves are generally used instead of latex.
- **Nitrile**—copolymer gloves permit dexterity and sensitivity, while standing up to heavy use (even after exposure to substances that cause other glove materials to disintegrate). OSHA states that nitrile protects against chlorinated solvents (e.g., trichloroethylene and perchloroethylene), oils, greases, acids, caustics, and alcohols. Nitrile is not recommended for use with strong oxidizing agents, aromatic solvents, ketones, or acetates.

Chemical- and liquid-resistant gloves must be long enough to prevent liquids from entering the top. Generally, the thicker the gloves, the greater the chemical resistance. The tradeoff is impaired grip and dexterity. Do not use these types of gloves when handling rough or sharp objects.

Before using chemical- and liquid-resistant gloves, inspect them for tears, punctures, discolorations, stiffness, or other damage or defects. One way to test a glove's protection is to fill it with water and then roll the top (cuff) toward the fingers to check for leaks. Reuse of chemical-resistant gloves should be evaluated carefully, considering the absorptive quality, toxicity of chemicals handled, duration of exposure, and glove storage temperature.

Insulating rubber gloves minimize exposure to electrical hazards. OSHA CFR 1910.137 details requirements for the selection, use, and care of these gloves.

Gloves for extreme temperatures (hot and cold) are discussed in the Special Types of PPE section.

Check your company's policies regarding whether gloves can be worn around rotating equipment and/or power tools.

FOOT AND LEG PROTECTION Foot and leg protection is used to minimize hazards such as the following:

- Impacts and/or crushing
- Falling or rolling objects
- Penetration by sharp objects
- Hot surfaces
- Exposure to hazardous substances (e.g., chemical, biological)
- Slippery surfaces

A variety of footwear and leg protection can be worn, based on the type of job or task. For example, you might be required to wear safety shoes or boots, rubber boots, flat soled shoes, high tops, or other types of protective footwear (Figure 22.16). Some types of footwear are not permitted (e.g., open toed shoes, sandals, and high heels).

Figure 22.16 Safety shoes and boots help prevent slipping, impact injuries, and exposure to hazardous substances.

CREDIT: BushAlex/Shutterstock.

Safety shoes or boots must meet ANSI minimum compression and impact performance standards (Z41-1991). ANSI-approved safety footwear provides toe protection and impact or compression protection. The type and amount of protection can vary. Shoe soles are typically nonslip and heat resistant. Some safety footwear includes steel toe boxes and/or metal insoles to prevent penetration. Leather is a common material used for the upper parts of safety shoes or boots.

Metatarsal guards, made of aluminum, steel, fiber, or plastic, can be strapped to the outside of shoes to protect the instep area from impact and compression hazards.

Toe guards also fit over the toes of shoes to provide protection from impact or compression. They can be made of aluminum, steel, or plastic.

Combination foot and shin guards protect the feet and lower legs. They can be used along with toe guards to provide added protection.

Leggings, made of leather, aluminized rayon, or other materials, can provide leg protection against a variety of hazards (e.g., falling or rolling objects, molten metal, sharp objects, hot surfaces).

The following are some other types of hazards and the proper footwear to use:

- Rubber or vinyl boots can provide protection against chemical splashes and spills.
- Proper footwear and shoe inserts can also protect against ergonomic hazards.
- Nonconductive footwear should be worn around electrical hazards. This type of safety shoe can prevent the wearer's feet from completing an electrical circuit to the ground. In dry conditions, they can protect against open circuits of up to 600 volts (depending on the type). These should be used along with other insulating PPE and additional precautions. However, the insulating protection can be reduced if the shoes get wet, the soles are worn down, or metal objects become embedded. And, following electrical safety precautions, the worker must not touch conductive, grounded objects. Nonconductive footwear must not be used in explosive or hazardous locations.
- Conductive footwear might be required in some situations to prevent the buildup of static electricity. Foot powder should not be used with conductive footwear, because it provides insulation and reduces the conductivity of the shoes. Socks made of nylon, wool, or silk can produce static electricity and should not be worn with conductive footwear. If working around electrical hazards, you should never wear conductive footwear.

The following are some tips for using and maintaining protective footwear and leg protection:

- Inspect them prior to each use, checking for wear and tear: cracks, holes, separation of materials, discoloration, thin spots, broken buckles, and broken laces.
- Look over the soles of shoes for embedded metal objects or other items.
- Follow the manufacturers' recommendations for cleaning and maintenance.

In some situations, chemical or biological substances can be spilled onto safety footwear. These substances can be absorbed by the shoe material or leak inside the top of the shoe. Use a safety shower to deluge yourself and the footwear.

Special Types of PPE

Special types of PPE can be required, based on the type of hazard and other conditions. The following are some common types of special PPE.

Fall protection (or fall arrest) devices can be used to prevent injuries from falls of four feet or greater. Fall protection consists of a full body harness, an anchor point, and a lanyard connecting the two. The harness is designed to evenly distribute forces of a fall to strong muscle groups that can better absorb these forces than other body parts. See Chapter 9, *Working Area and Height Hazards* for more information about falls.

Temperature protection includes both hot and cold temperature gear. For high-temperature environments, PPE can include the following:

- Reflective clothing
- Insulated suits
- Aramid fiber gloves (protect against hot or cold, and are cut or abrasion resistant)
- Synthetic gloves (protect against hot or cold, are cut or abrasion resistant, and can handle some diluted acids)

- Aluminized gloves (provide reflective and insulating protection)
- Tinted face shields
- Ice vests and cooling bandanas
- Water cooled garments
- Cooling inserts for hard hats

For low-temperature environments, PPE can include the following items:

- Polyester or polypropylene underwear
- Polypropylene liner socks
- Outer jackets that can be opened at the waist, neck, and wrists to control the release or retention of heat; these can also include side vents and underarm vents
- Heated protective clothing
- Gloves or mittens
- Hard hat liners
- Leather upper boots with rubber bottoms and felt lining and insoles
- Eye protection fitted to prevent exhaled moisture from causing frost or fog on the eye piece(s); eye protection can also be tinted to prevent glare

Safety Showers and Eyewashes

Eyewash stations and safety (or emergency) showers can provide on-the-spot decontamination using a large quantity of water or other flushing fluid, serving as a backup to PPE if hazardous material exposure occurs. An exposed worker can flush away the hazardous substance using an approved fluid such as potable (drinking) water or treated water. Remember that water does not neutralize any contaminants, but it does dilute and wash them off the affected area.

Eyewash stations are either fixed units or portable and provide a stream of flushing fluid directly to the eyes and face (Figure 22.17A). Some eyewash stations look like drinking fountains with two streams, while others are containers filled with liquid. Safety showers provide a high rate and high pressure flow of water to rinse away contaminants from the face or body; they can also be used to put out clothing fires (Figure 22.17B).

A.

B.

Figure 22.17 Eyewash stations are used to flush hazardous substances from the eyes. **B.** Safety showers are used to wash hazardous substances off the body.

CREDIT: A. Khamkhlai Thanet/Shutterstock. **B.** Choksawatdikorn/Shutterstock.

Both eyewash stations and showers are designed to turn on quickly and operate continuously with little interaction from the worker. Some eyewash stations and safety showers are a combined unit. Eyewash stations and safety showers can include an alarm to alert others that the station or shower is in use.

When a worker is exposed, time is critical. Eyewash and safety showers should be located no more than 10 seconds from potential hazards. Locations of eyewash stations and safety showers should be marked with signs and well lit. If used quickly and properly, eyewashes and safety showers can greatly reduce the severity of a hazardous material exposure.

Workers must be familiar with the materials they are working with and read the appropriate safety data sheets (SDSs) before they are exposed. Some materials react with water and should not be removed using an eyewash station or safety shower (e.g., sodium reacts with water to produce hydrogen, which is an extremely flammable gas). Process technicians must be familiar with the location and operation of eyewashes and safety showers in their work area. Process technicians should locate eyewashes and safety showers as soon as they enter the area. In an emergency, the worker may not be able to see well enough to find the eyewash or safety shower.

A potential drawback to eyewash stations and safety showers that use potable water is that the water can contain chemicals and other substances that interact with the contaminant and aggravate the situation. Portable eyewash stations may not contain enough fluid to properly flush the contaminant.

Another type of device is called a drench or deluge hose, which is typically attached to a sink or faucet. These devices are not recommended for use as eyewash stations or safety showers. However, if necessary they can be used to drench a worker's head and body; they should not be used on the eyes due to the high water pressure. They can also be used to spot rinse an area or to assist a victim who cannot stand or is unconscious.

The following are some tips for eyewash stations and safety showers:

- Flush (or irrigate) the affected area for the recommended amount of time. Refer to Table 22.1.
- If you wear contacts, wash your hands thoroughly and then remove the lenses to prevent contaminants from being trapped between the eye and the lens.
- Avoid using a safety shower as an eye wash (the water pressure can damage the eyes).
- Seek medical evaluation after using an eyewash station or safety shower; they are not a substitute for medical care.

ANSI has created a standard for emergency eyewash and shower equipment (ANSI Z358.1-2004), and recommends that the affected body part be flushed immediately and thoroughly for at least 20 minutes using a lot of clean fluid (e.g., water). Flushing times can vary, based on the chemical and its properties. Table 22.1 illustrates some recommended minimum times, based on the type of contaminant.

Table 22.1 Minimum Recommended Flushing Times for Eyewash Stations and Safety Showers

Contaminant	Minimum Recommended Flushing Times
Mild chemical irritant	5 minutes
Unknown	20 minutes
Moderate to severe chemical irritant	20 minutes
Nonpenetrating corrosive chemical	20 minutes
Penetrating corrosive chemical	60 minutes

22.3 Levels of PPE Protection

OSHA and EPA regulations have determined four classes or levels of PPE protection (Table 22.2) based on the type of work being performed and the probability of the worker coming into contact with hazardous materials. Companies must identify the hazard(s) and determine the concentration (typically parts per million, or PPM). Then appropriate PPE is

Table 22.2 Four Classes of PPE

Level	Designation	Probability of Contact with Hazardous Materials	Examples of PPE Used*
A	Highest	Highly probable	Highest level of protection, usually level D plus an air-supplying respirator (e.g., SCBA), totally encapsulating chemical protective (TECP) suit, rubber boots, and chemical gloves
B		Probable	Added protection, usually level D plus a full chemical protective suit, air-supplying respirator, face shield, goggles (in place of safety glasses), and rubber boots
C		Possible	Added protection, usually level D plus PPE (e.g., a face shield, chemical-resistant gloves, a chemical protective jacket or slicker jacket, and potentially a respirator)
D	Lowest	Low possibility	Minimal protection. This is typically the daily work uniform and PPE that process technicians must wear (e.g., FRC, safety boots, hard hat, safety glasses, and hearing protection)

*Company policy dictates the exact PPE requirements.

selected and a list is developed, including skin and respiratory protection, for specific tasks and work areas. These lists are generally posted in appropriate areas around the facility and included in standard operating procedures (SOPs).

Level A provides full protection of skin, the respiratory system, eyes, membranes, and the entire body. It is used in situations where contact with hazardous materials (e.g., sulfuric acid) is very likely, and inhalation and absorption hazards exist.

Level B provides protection in situations where contact with hazardous materials is likely, and absorption of chemicals through the skin is the chief hazard. Level B provides the same level of respiratory protection as Level A but less skin protection. It is used when IDLH (immediately dangerous to life and health) concentrations of substances do not represent a skin hazard and levels do not meet the criteria for air-purifying respirators, but a high level of respiratory protection is still needed.

Level C PPE provides the same level of skin protection as level B, with a lower level of respiratory protection. The potential absorption hazard is lower than levels A and B.

Level D typically provides minimum skin protection and no respiratory protection.

22.4 Government Regulations

The following are OSHA regulations relating to medical or first aid requirements and personal protective equipment.

OSHA 1910 Subpart K: Medical and First Aid and Related Regulations

Employers are responsible for determining their own medical and first aid requirements. They must develop a plan for handling the safety hazards to which their employees are exposed on the job. These plans do not require approval by OSHA; however, during an inspection, the plan is evaluated for accuracy.

RECOGNITION AND EVALUATION To determine their needs, employers must evaluate the workplace for requirements. They must consider the following areas when determining what those needs are:

- Location and availability of medical facilities and emergency services
- Availability of medical personnel to consult on occupational health issues

- Types of accidents that could reasonably occur at the workplace
- Response time of external emergency services
- Number and locations of employees at the plant
- Corrosivity of materials used at the facility
- First aid supplies that should be available
- Level of training required for employees who will render first aid

MEDICAL AND FIRST AID PLAN After evaluating the workplace, employers must design and implement a program that is tailored to the specific work site. Elements of the program must include the availability of medical personnel for consultation with employees. Employers must provide the names and telephone numbers for the medical professionals with whom the employer has agreements. Emergency telephone numbers must be conspicuously located by each plant telephone. In addition, sufficient ambulance service must be available to handle an emergency. This requires ensuring that ambulance services are familiar with the plant location, access routes, and hospital locations.

FIRST AID RESPONDERS Employers are required to have at least one person trained in first aid at the work site if serious or life-threatening injuries can be reasonably expected. The trained personnel must be available within 15 minutes for serious injuries and within 4 minutes for life-threatening injuries.

Multiple individuals should be trained in order to provide coverage when other responders are unavailable. The responder(s) should be designated and the other workers should know who they are and how to contact them in an emergency. Trained responders must have a current first aid certificate (Figure 22.18).

Figure 22.18 Process technicians should consider becoming certified in CPR. Prompt use of CPR in an emergency could save a life.

CREDIT: Sorn340 Images/Shutterstock.

BLOODBORNE PATHOGENS Bloodborne pathogens are microorganisms present in human blood or bodily fluids that are capable of causing disease in humans. These pathogens include, but are not limited to, the hepatitis B virus (HBV) and the human immunodeficiency virus (HIV). In most process facilities, it is highly unlikely that employees will be exposed to bloodborne pathogens while performing their normal job tasks. However, they are at risk of exposure if they are in close proximity to an accident victim. Special training is required when exposure is more likely, as is the case for a first aid provider. Various training courses are required for different types of responders.

Employees who are exposed to waste treatment systems may require vaccinations against infectious diseases, such as HBV. First aid kits typically include PPE to protect responders from bloodborne pathogens. See Chapter 4, *Recognizing Biological Hazards* for more information.

EMERGENCY EQUIPMENT First aid kits must be available at the work site. The contents of the kits must be determined through direct consultation with a physician. The contents will vary from facility to facility (or even in different parts of a facility, based on the types of hazards at the facility or area). Eyewash stations and emergency showers are required in locations where corrosive materials are used. The equipment must provide large amounts of clean water and be pressure-controlled and clearly identified.

TRAINING AND RECORDKEEPING First aid training is recommended by OSHA during initial job training and on an ongoing basis. The Red Cross and National Safety Council provide first aid and CPR courses.

Employers are required to maintain first aid and medical treatment records for all employees who receive treatment on the job. These records are subject to review in the event of a workplace audit.

Personal Protective Equipment Regulations

OSHA 1910.132—PERSONAL PROTECTIVE EQUIPMENT (PPE) The OSHA Personal Protective Equipment (PPE)—29 CFR 1910.132 standard aims to prevent worker exposure to potentially hazardous substances through the use of equipment that establishes a barrier between the hazardous substance and the individual's eyes, face, head, respiratory system, and extremities.

This standard requires employers to assess workplace hazards to do the following:

- Determine what PPE is necessary.
- Provide required PPE to their employees.
- Train employees in the proper use and care of the PPE.
- Ensure that employees use the PPE appropriately.
- Determine the limitations of the PPE.

OSHA 1910.133—PPE: EYE AND FACE PROTECTION The OSHA Personal Protective Equipment (PPE)—29 CFR 1910.133 standard is intended to prevent worker exposure to potentially hazardous substances through the use of appropriate eye or face protection. The PPE will establish a barrier between the hazardous substance and the individual's eyes and face.

OSHA 1910.134—PPE: RESPIRATORY PROTECTION The OSHA Personal Protective Equipment (PPE)—29 CFR 1910.134 standard is intended to prevent worker exposure to potentially hazardous substances through the use of appropriate respirators when they are deemed necessary to protect the health of the worker.

OSHA 1910.138—PPE: HAND PROTECTION The OSHA Personal Protective Equipment (PPE)—29 CFR 1910.138 standard is intended to prevent worker exposure to potentially hazardous substances through the use of appropriate hand protection when workers' hands are exposed to hazards such as absorption of chemicals through the skin, punctures, chemical burns, temperature extremes, and thermal burns.

Summary

OSHA requires that employees be provided with a safe and healthy workplace that is reasonably free of occupational hazards. However, process technicians can be exposed to chemical, biological, physical, and ergonomic hazards inherent to working in a process facility. Although every effort is made to prevent accidents and emergencies, they can still occur on the job because a process industry work site can pose a variety of potential hazards.

Company policies and procedures determine whether process technicians can provide first aid to victims. Often, an emergency response team (or first responders) and/or a resident medical staff will handle emergencies and accidents, including first aid treatment. At the very least, the process technician is required to report emergencies and accidents in a timely way to the proper authorities. Your company will train you on how to report emergency situations and accidents, along with other basic emergency procedures (potentially including first aid training).

To prevent or minimize hazards, government and the process industries have implemented engineering controls, administrative controls, and the use of personal protective equipment (PPE). Process technicians must understand the proper selection, use, care, and maintenance of PPE.

Checking Your Knowledge

1. Define the following terms:
   a. CPR
   b. First-degree burns
   c. Second-degree burns
   d. Third-degree burns
2. List four general recommendations for dealing with injuries in the workplace.
3. Name two types of eye protection that can prevent eye injuries.
4. List three possible impact injuries.
5. ____ resistant clothing can be worn to minimize the hazards of burns.
6. Name at least three signs of electrical shock.
7. List four types of PPE that can be used to minimize exposure to chemical hazards.
8. Name the two main groups responsible for promoting standards that PPE provide proper protection.
9. What are the 3 Cs of proper fit for PPE?
10. ____ occurs when hazardous materials or other forces (sunlight, heat, moisture) break down the PPE properties through contact over time.
    a. Penetration
    b. Contamination
    c. Permeation
    d. Degradation
11. Describe the two main types of hearing protection.
12. (*True or False*) Safety glasses or goggles can be worn with a face shield.
13. What class of hard hat provides impact and penetration resistance along with limited voltage protection (up to 2,200 volts)?
    a. A
    b. B
    c. C
    d. D
14. Define the acronym TECP.
15. List four types of chemical- and liquid-resistant glove materials.
16. (*True or False*) Safety shoes or boots must meet ANSI minimum compression and impact performance standards.
17. (*True or False*) Eyewash stations and showers can provide on-the-spot decontamination using a large quantity of water or other flushing fluid.
18. Which of the following PPE levels provides the highest amount of protection?
    a. A
    b. B
    c. C
    d. D
19. Employers are required to have ___ person trained in first aid at the work site if serious or life-threatening injuries can be reasonably expected.
20. Which of the following is addressed by OSHA regulation 1910.132?
    a. Protective personal equipment
    b. Eye and face protection
    c. Respiratory protection
    d. Hand protection

NOTE: Answers to Checking Your Knowledge questions are in Appendix A.

Student Activities

1. Research at least three different types of PPE that protect the body. Make a list, describing the PPE, limitations, proper fit, use, and care and maintenance requirements.
2. Obtain at least three different types of liquid-resistant gloves, then use them to perform various tasks. After repeated use, perform a leak test (place water in the glove, roll the top toward the fingers, and then check for leaks). Did of the any gloves leak? If so, what were they made of?
3. Using at least three different types of PPE (e.g., safety glasses, hearing protection, and hard hat), correctly adjust the PPE so it can be worn together comfortably. Demonstrate the process to your fellow students.
4. Attend a course and learn how to properly perform CPR or first aid. Write a three-page paper describing the value of your experience.