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Firefighter Personal Protective Equipment



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Chapter 6



Key Terms

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NFPA® Job Performance Requirements

This chapter provides information that addresses the following job performance requirements of NFPA® 1001, *Standard for Fire Fighter Professional Qualifications* (2013).

Firefighter I
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5.3.2

5.5.1

Firefighter I Chapter Objectives

- 1. Describe the purpose of personal protective equipment. (5.1.1)
- 2. Describe characteristics of each type of personal protective equipment. (5.3.2)
- 3. Summarize guidelines for the care of personal protective clothing. (5.1.1, 5.5.1)
- 4. Explain the safety considerations for personal protective equipment. (5.3.1)
- 5. Identify respiratory hazards. (5.3.1)
- 6. Identify types of respiratory protection equipment. (5.3.1)
- 7. Describe the limitations of respiratory protection equipment. (5.3.1)
- 8. Explain methods for storing respiratory protection equipment. (5.5.1)
- 9. Describe general donning and doffing considerations for protective breathing apparatus. (5.3.1)
- 10. Summarize general considerations for protective breathing apparatus inspections and care. (5.1.1, 5.5.1)
- 11. Summarize safety precautions for refilling SCBA cylinders. (5.5.1)
- 12. Explain procedures for replacing SCBA cylinders. (5.3.1)
- 13. Explain safety precautions for SCBA use. (5.3.1)
- 14. Describe nonemergency and emergency exit indicators. (5.3.1)
- 15. Describe nonemergency exit techniques. (5.3.1)
- 16. Demonstrate the method for donning structural personal protective clothing for use at an emergency. (Skill Sheet 6-I-1, 5.1.2, 5.3.1)
- 17. With structural personal protective clothing in place, demonstrate the over-the-head method of donning an SCBA. (Skill Sheet 6-I-2, 5.3.1)
- With structural personal protective clothing in place, demonstrate the coat method for donning an SCBA while seated. (Skill Sheet 6-I-3, 5.3.1)
- 19. With structural personal protective clothing in place, demonstrate the method for donning an SCBA while seated. (Skill Sheet 6-I-4, 5.3.1)
- 20. Doff personal protective equipment, including respiratory protection, and prepare for reuse. (Skill Sheet 6-I-5, 5.1.2)
- 21. Demonstrate the steps for inspecting an SCBA. (Skill Sheet 6-I-7, 5.5.1)
- 22. Demonstrate the steps for cleaning and sanitizing an SCBA. (Skill Sheet 6-I-7, 5.5.1)
- 23. Demonstrate the method for filling an SCBA cylinder from a cascade system, wearing appropriate PPE, including eye and ear protection. (Skill Sheet 6-1-8, 5.3.1)
- 24. Demonstrate the method for filling an SCBA cylinder from a compressor/purifier system, wearing appropriate PPE, including eye and ear protection. (Skill Sheet 6-I-9, 5.3.1)
- 25. Demonstrate the one-person method for changing an SCBA cylinder. (Skill Sheet 6-I-7, 5.3.1)
- 26. Demonstrate the two-person method for changing an SCBA cylinder. (Skill Sheet 6-I-7, 5.3.1)

Chapter 6 Firefighter Personal Protective Equipment





Case History

In 2002, Mark Noble, a nineteen-year veteran of the Olympia (WA) Fire Department, was diagnosed with brain cancer. During his treatment, Mark began to research the connection between firefighters and cancer. He learned that firefighters are exposed to highly toxic substances in virtually every fire and that some toxins can accumulate in the body after repeated exposures. These potentially deadly toxins include asbestos, benzene, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), carbon monoxide (CO), and

other products of combustion that are present during the overhaul phase of a fire.

In his research, Mark found that firefighters are twice as likely as the general public to develop intestinal, liver, testicular, and prostate cancer, non-Hodgkin's lymphoma, and malignant melanoma. They are three times as likely to develop skin, brain, and bladder cancer, as well as leukemia. They are also four times as likely to develop kidney cancer (**Figure 6.1, p.260**).

In 2005, Mark Noble died at the age of 47. The brain cancer that killed him was most likely caused by the toxins he was exposed to in the fire service. Mark loved being a firefighter, but he said that if he had it to do over again, he would wear his SCBA more, and he would be more conscientious about attaching exhaust collection hoses to the apparatus.

Permission to use this information was granted by Mrs. Rebecca Noble and ERGOMETRICS & Applied Personnel Research, Inc., who produced a video interview with Mark during his final months. The video is available at the following Website: www.ergometrics.org.

As a firefighter and emergency responder, you will work in a wide variety of hazardous environments. To protect your life and health, you must wear proper safety equipment at all times. This chapter provides an overview of two critical types of safety equipment: personal protective equipment (PPE) and respiratory protection. You will learn about the different types of this equipment, as well as their functions, proper usage, and maintenance.

Personal Protective Equipment

Personal protective equipment (PPE) is the personal protective clothing (PPC), respiratory protection equipment, and personal alert safety system (PASS) you will wear during emergency responses. It is designed to protect you from hazards and minimize Personal Protective Equipment (PPE) — General term for the equipment worn by fire and emergency services responders; includes helmets, coats, trousers, boots, eye protection, hearing protection, protective gloves, protective hoods, self-contained breathing apparatus (SCBA), and personal alert safety system (PASS) devices. *Also known as* Bunker Clothes, Full Structural Protective Clothing, Protective Clothing, Turnout Clothing, or Turnout Gear.

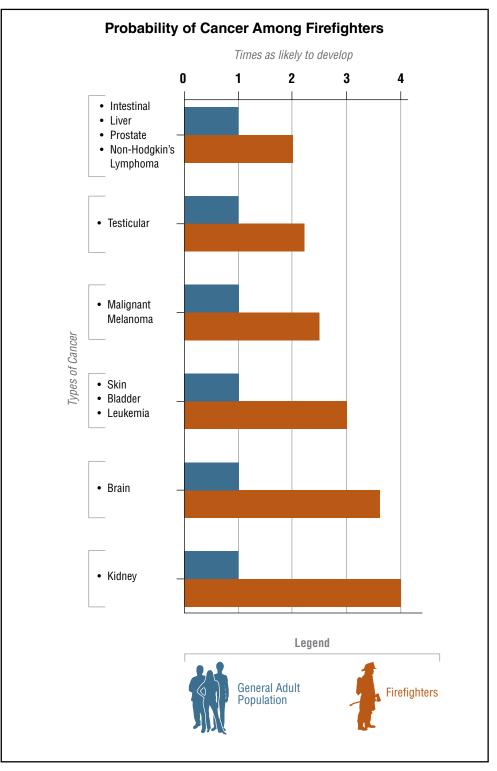


Figure 6.1 Firefighters are exposed to a greater range and concentration of hazards than the general public, and they have a higher likelihood of several types of cancers because of that exposure.



Figure 6.2 Protective equipment and clothing are tailored to the hazards that a first responder will face.

the risk of injury or fatality (**Figure 6.2**). Your PPC includes helmets, coats, trousers, boots, eye protection, hearing protection, protective gloves, and protective hoods. Its use is mandated by NFPA[®] 1500, *Standard on Fire Department Occupational Safety and Health Program*, and all equipment must be designed and constructed based on NFPA[®] standards. Design and construction requirements for SCBA and PASS devices are covered in NFPA[®] 1981, *Standard on Open-Circuit Self-Contained Breathing Apparatus (SCBA) for Emergency Services*, and NFPA[®] 1982, *Standard on Personal Alert Safety Systems (PASS)*, respectively.

Different emergency operations require different kinds of PPE. For example, some emergency types require full sets of PPE, including respiratory protection, while others require only protective clothing. Types of personal protective clothing include:

- Structural fire fighting protective clothing
- Wildland fire fighting protective clothing
- Roadway operations protective clothing
- Emergency medical protective clothing
- Special protective clothing
- Station and work uniforms

Structural Fire Fighting Protective Clothing

All personal protective clothing designed for **structural** and **proximity** fire fighting must meet the requirements of NFPA® 1971, *Standard on Protective Ensembles for Structural Fire Fighting and Proximity Fire Fighting*. This standard addresses the requirements for helmets, coats, trousers, boots, eye protection, protective gloves, and protective hoods.

Structural Fire Fighting —

Activities required for rescue, fire suppression, and property conservation in structures, vehicles, vessels, and similar types of properties.

Proximity Fire Fighting —

Activities required for rescue, fire suppression, and property conservation at fires that produce high radiant, conductive, or convective heat; includes aircraft, hazardous materials transport, and storage tank fires. **Figure 6.3** NFPA® 1971 regulates the clothing components that comply with the standard.



NFPA® 1971 requires that all components must include a permanent label that shows compliance with the standard (**Figure 6.3**). This label contains the following statement:

THIS STRUCTURAL FIRE FIGHTING PROTECTIVE (name of component) MEETS THE (name of component) REQUIREMENTS OF NFPA® 1971, (current edition) EDITION.

Labels must also include the following information:

- Manufacturer's name, identification, or designation
- Manufacturer's address
- Country of manufacture
- Manufacturer's identification, lot, or serial number
- Month and year of manufacture
- Model name, number, or design
- Size or size range
- Principal materials of construction
- Footwear size and width (where applicable)
- Cleaning precautions

Personal protective clothing components must be compatible with each other to provide the level of protection intended by the NFPA® standard. Each component is designed to protect you from specific hazards and may not protect you from other types of hazards. For instance, structural personal protective clothing offers no protection against many types of hazardous materials.

Firefighters should never alter their protective clothing. Changing, adding, or removing components may void the manufacturer's warranty, affect your workers' compensation benefits, and endanger your life. Alterations include removing the moisture barrier or liner of coats and trousers, sewing hooks, loops, or clasps to the outer shell, and adding combustible decals to the helmet.





Figure 6.4 Protective clothing may create its own hazards including the entrapment of heat.

Structural personal protective clothing is designed to cover all portions of your skin when you are reaching, bending, or moving. It is also designed to prevent heat transfer from the fire to your body. However, one limitation of this design is that it also prevents heat from being transferred *away* from your body. Usually your body cools itself by sweating, but the protective clothing traps body heat and moisture inside the clothing. This may significantly increase your breathing and heart rate, skin temperature, core temperature, and physiological stress (**Figure 6.4**). If environmental conditions allow it, open your protective clothing to permit airflow around your body during authorized breaks. This will lessen heat stress and reduce your heart rate.



Hazards Determine the PPE

Always wear the correct PPE that is designed to protect you from the specific type of hazard(s) presented by the incident.



Figure 6.5 a Helmets have developed over time to address specific incident needs.

Helmet — Headgear worn by firefighters that provides protection from falling objects, side blows, elevated temperatures, and heated water.



Figure 6.5 b The features of a helmet should be used with the necessary safeguards in place to prevent injuries.



Figure 6.5 c Unique styles of helmets should be used according to their specific purposes and the AHJ.

Helmets

One of the primary concerns for firefighters is head protection. **Helmets** are manufactured in a wide variety of designs and styles (**Figures 6.5 a-c**). They are designed to provide multiple benefits during structural fire fighting operations, including:

- Preventing heated or scalding water and embers from reaching the ears and neck
- Protecting the head from impact injuries caused by objects or falls
- Providing protection from heat and cold

In addition to providing protection, helmets can also help to identify personnel. Shell color indicates the firefighter's rank, markings indicate the unit, and removable identification labels indicate accountability (**Figures 6.6 a-d**). All of these uses are based on a department's standard operating procedures (SOPs).

To properly protect you, your helmet must be worn correctly. Place the helmet on your head, secure the chin strap under your chin and tighten it, and fold the ear flaps down to cover your ears and neck. You must fold the ear flaps down even if you are wearing a protective hood. Some helmets also have a ratchet at the back of the headband to allow you to adjust the fit.



Figure 6.6 a Personal identification may be found on the front panel of a helmet.



Figure 6.6 b The markings on a helmet often indicate rank and unit.



Figure 6.6 c A responder's name or nickname is often marked on the back of his or her helmet.



Figure 6.6 d Accountability tags may fit conveniently inside the rear edge of a helmet for easy accessibility before entering an incident scene.



Figure 6.7 a SCBA facepieces include eye protection.



Figure 6.7 b Helmet mounted faceshields may serve as partial eye protection.



Figure 6.7 c Goggles are commonly used in emergency incidents.



Figure 6.7 d Safety glasses guard against slow-travelling hazards.

Eye Protection Devices

Eye injuries are some of the most common injuries at emergency incidents, but they are not always reported because they are not always debilitating. Although eye injuries can be serious, they are fairly easy to prevent. Eye protection comes in many forms including SCBA facepieces, helmet-mounted faceshields, goggles, and safety glasses (Figures 6.7 a-d).

Helmets must be equipped with faceshields or goggles. Faceshields alone do not provide adequate protection from flying particles or splashes and are intended to be used in combination with a primary form of eye protection. NFPA® 1500 requires that goggles or other appropriate primary eye protection be worn when participating in operations where protection from flying particles or chemical splashes is necessary. During fire fighting operations, your primary eye protection is your SCBA facepiece. But in other situations, eye protection is needed when respiratory protection is not required. Some of these situations include:

- Emergency medical responses where exposure to body fluids is possible
- Vehicle extrications
- Wildland and ground cover fires
- Industrial occupancy inspections
- Station maintenance

These situations call for safety glasses or goggles, which protect against approximately 85 percent of all eye hazards. Several styles are available, including some that fit over prescription glasses. Prescription safety glasses are another option, although these must have frames and lenses that meet American National Standards Institute (ANSI) Standard Z87.1, Occupational and Educational Personal Eye and Face Protection Devices.

In fire department facilities and maintenance areas, you should be aware of warning signs posted near power equipment requiring the use of eye protection. Always follow your department's safety policies and procedures regarding appropriate eye protection.

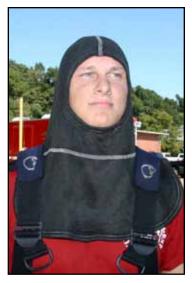


Figure 6.8 Protective hoods provide a continuous layer of coverage for the head and neck.

Protective Hood — Hood designed to protect the firefighter's ears, neck, and face from heat and debris; typically made of Nomex®, Kevlar®, or PBI®, and available in long or short styles.

Protective Coat — Coat worn during fire fighting, rescue, and extrication operations.

Protective Hoods

Protective hoods are fabric coverings that protect your ears, neck, and face from exposure to heat, embers, and debris. They cover areas that may not be protected by the SCBA facepiece, helmet, ear flaps, or coat collar. The protective hood's face opening has an elastic edge that fits tightly to the SCBA facepiece, forming a seal. Hoods are typically made of fire-resistant material and are available with long or short skirts (**Figure 6.8**). The skirts are designed to fit inside the protective coat, forming a continuous layer of protection.

Pull the hood on before the protective coat to help keep the hood's skirt under the coat. To ensure a secure seal between the hood and the SCBA facepiece, secure the facepiece first before pulling up the hood. This way you will not compromise the facepiece-to-face seal.

Protective Coats

NFPA® 1971 requires that all **protective coats** used for structural fire fighting be made of three components: the outer shell, moisture barrier, and thermal barrier (**Figure 6.9**). These barriers trap insulating air that prevents heat transfer from the fire to your body. They also provide limited protection from direct flame contact, hot water, steam, cold temperatures, and other environmental hazards. Each component is important to your safety and should never be compromised. Removing the liner and wearing only the shell compromises the design of the coat, increases the likelihood of injuries, and voids the manufacturer warranty.



All layers of the protective coat must be in place during any fire fighting operation. Failure to wear the entire coat and liner system during a fire may expose you to severe heat resulting in serious injury or death.



Figure 6.9 The three component layers of a protective coat work together to provide resistance against hazards in the environment and are identified as: a) the outer shell, b) the moisture barrier, and c) the thermal barrier. Protective coats have many design features that provide protection and convenience (Figures 6.10 a-e, p. 268). Design features required by NFPA® 1971 include:

- **Retroreflective trim** Strips of reflective trim on the torso and sleeves make it more visible at night or in low light conditions.
- Wristlets Fabric interface between the end of the sleeve and the palm of the hand that protects the wrist from water, embers, and other debris. Also keeps coat sleeves from riding up when reaching.
- **Collars** Protects the neck from water, embers, and other debris. The collar must be turned up under the helmet ear flap.
- Closure system Snaps, clips, zippers, or Velcro[®] fasteners that secure the front of the coat.
- **Drag Rescue Device (DRD)** Harness and hand loop at the back of the neck that enables a rescuer to grab and drag a downed firefighter.

Coats are typically reinforced in high compression areas, such as the shoulders, and areas prone to wear, such as the elbows. Optional design features such as cargo, radio, or SCBA facepiece pockets are also common, based on local requirements. These optional features must be attached by the manufacturer to meet the NFPA® standard.

Protective Trousers

Protective trousers are constructed from the same fabric, moisture barrier, and thermal layering used in protective coats (**Figure 6.11, p. 269**). High compression areas and areas prone to wear are reinforced, and cargo or patch pockets may be attached for carrying gloves and small tools. Heavy-duty suspenders are used to hold the trousers up. Closure systems are the same as those found on the protective coat.

Protective Gloves

Protective gloves protect hands and wrists from heat, steam, or cold penetration, and resist cuts, punctures, and liquid absorption. At the same time, gloves must allow enough dexterity and tactile feel for you to perform your job effectively. For instance, gloves must permit you to grasp tools and nozzles or manipulate small objects such as control knobs on portable radios (**Figure 6.12, p. 269**). Properly worn, the gloves cover the wristlet of the protective coat to form a complete seal. Gloves worn for structural fire fighting must be NFPA®-compliant for this type of activity.

Protective Footwear

Fire fighting boots are available in a variety of styles and materials (**Figures 6.13 a and b, p. 269**). They protect the foot, ankle, and lower leg from:

- Puncture wounds to the sole caused by nails, broken glass, and other sharp objects
- Crushing wounds to the toes and instep
- Scalding water or contaminated liquids
- Burns from embers and debris

Boots have a steel inner sole and a steel or reinforced toe cap and must be high enough to protect the lower leg. The outer shell may be made of rubber, leather, or other water-resistant material. Thermal, physical, and moisture barriers are required inside the shell. Boot tops fit inside the trouser legs, providing a complete barrier even when you kneel down. Protective Trousers — Trousers worn to protect the lower torso and legs during emergency operations. *Also known as* Bunker Pants or Turnout Pants.

Protective Gloves — Protective clothing designed to protect the hands.

Fire Fighting Boots — Protective footwear meeting the design requirements of NFPA®, OSHA, and CAN/CSA Z195-02 (R2008).



Figure 6.10 a Reflective trim catches light and reflects it to enhance the visibility of responders at night or in low-light conditions.



Figure 6.10 c Coat collars prevent embers, water, and other debris from getting under the coat.



Figure 6.10 d A coat closure system may include more than one mechanism to ensure a complete seal.



Figure 6.10 b Wristlets are built into the ends of coat sleeves to provide a protective interface between sleeves and gloves.



Figure 6.10 e A loop on the back of protective clothing serves as a handle to aid in the rescue of a distressed firefighter.



Figure 6.11 Because of their weight, protective trousers are supported in place with suspenders.



Figure 6.12 Protective gloves cover the hands and coat wristlet to provide protection against common hazards.



Figure 6.13 a Fire fighting boots protect the foot and ankle from hazards routinely found at an incident scene.



Figure 6.13 b Styles of fire fighting boots may vary but their common purpose is to protect a firefighter's feet and lower legs.

Hearing Protection — Device that limits noise-induced hearing loss when firefighters are exposed to extremely loud environments, such as apparatus engine noise, audible warning devices, and the use of power tools and equipment.



Figure 6.14 Ear muffs are one form of hearing protection that can be used during activities with high noise exposure levels.

Personal Alert Safety System (PASS) — Electronic lack-ofmotion sensor that sounds a loud alarm when a firefighter becomes motionless. It can also be manually activated.

Hearing Protection Devices

Firefighters are exposed to a variety of loud noises in the fire station, during training, en route to incidents, and at the emergency scene. **Hearing protection** devices guard against temporary and permanent hearing loss. They are not required by NFPA® 1971, but they are required by NFPA® 1500.

To comply with this standard, departments must protect firefighters from the effects of harmful noise. Eliminating or reducing noise is the best solution, but sometimes this is not possible. In these cases, departments must provide hearing protection devices and establish a hearing conservation plan.

Hearing protection is most commonly used when riding on an apparatus where the noise exceeds maximum noise exposure levels (90 decibels in the U.S., 85 decibels in Canada). Intercom/ear protection systems are the most effective for this purpose, because they also allow the crew to communicate with each other or monitor radio communications. Hearing protection is also required during the operation of power tools, generators, and the apparatus pump, and when testing the PASS device (**Figure 6.14**).

However, hearing protection is impractical in some situations, and may even be dangerous. For example, during structural fire fighting, it prevents you from communicating with other firefighters and hearing radio transmissions, changes in fire behavior, or calls from a trapped victim.

Personal Alert Safety Systems (PASS)

Personal alert safety systems (PASS) emit a loud alarm to alert other personnel that a firefighter is in danger. The alarm is activated when a firefighter is motionless for more than 30 seconds, or when a firefighter presses the emergency button. In some models, it may be activated when the temperature exceeds a preset limit. The alarm must be at least 95 decibels (dBA) and must go off continuously for at least one hour.

PASS devices assist rescuers attempting to locate trapped, unconscious, or incapacitated firefighters. They are particularly useful in total darkness, dense smoke, or confined spaces. Some devices are stand-alone units that are manually activated. Other devices are integrated units connected to the SCBA regulator that are automatically activated when the main air supply valve is opened (**Figures 6.15 a and b**). SCBA-mounted devices can also be activated manually, without opening the cylinder valve.

PASS devices have at least three settings: *off, alarm*, and *sensing*. They also have a pre-alarm mode that activates if you are motionless for 30 seconds. This pre-alarm tone is different from the full alarm tone and is intended to prevent false alarms.

You must learn how to turn the unit from *off* to *sensing* (on) and to manually activate the alarm. You are also responsible for testing, maintaining, and activating your PASS device according to your department's SOP, manufacturer's instructions, NFPA® 1500, and NFPA® 1982, *Standard on Personal Alert Safety Systems (PASS)*.

Wildland Personal Protective Clothing

Personal protective clothing used for structural fire fighting is generally too bulky, heavy, and hot to be practical for wildland fire fighting. NFPA® 1977, *Standard on Protective Clothing and Equipment for Wildland Fire Fighting* contains the specifications for wildland fire fighting personal protective clothing and equipment (**Figure 6.16**). Wildland personal protective clothing and equipment includes:



Figure 6.15 a A stand-alone PASS device is not integrated with other safety equipment.



Figure 6.15 b An integrated PASS unit activates automatically when the air supply valve is opened. *Courtesy of James Nilo.*



Figure 6.16 Wildland personal protective clothing is minimal compared to structural fire fighting clothing.

- Gloves Made of leather or inherently flame-resistant materials. They protect the hand and wrist from sharp or hot objects, temperature extremes, and scalding water.
- **Goggles** Protect the eyes from ash, embers, dust, and other particulates. Must meet ANSI Z87.1, *Occupational and Educational Eye and Face Protection Devices*.
- Jackets Made of high-strength, flame-resistant fabric, such as Aramid, or treated cotton. May have a thermal liner for use in cold climates. The cuffs close snugly around the wrists, and the front of the jacket must close completely from hem to neck.
- **Trousers** Made of the same material and design as the jackets. The leg cuffs must close securely around the boot tops.
- **One-piece jumpsuits** One-piece protective garments are similar in design to the two-piece jacket and trousers ensemble.
- Long-sleeve shirts Protective shirts are worn under the jackets and are of similar design.
- Helmet A lightweight helmet with chin straps that provides impact, penetration, and electrical insulation protection.
- **Face/neck shrouds** Flame-resistant fabric that attaches to the helmet and protects the face and neck.
- Footwear Typically lace-up safety boots with lug or grip-tread soles. Must be high enough to protect the lower leg. Because the steel toes in ordinary safety boots absorb and retain heat, they are not recommended for wildland fire fighting.
- Fire shelter Fire-resistant aluminized fabric covers that protect the firefighter from convected and radiant heat (Figure 6.17). Its use is required by NFPA® 1500, and its design must meet the United States Department of Agriculture (USDA) Forest Service Specification 5100-606.
- Load-carrying or load-bearing equipment Belt and suspender systems that distribute the weight of the firefighter's equipment including tools, water bottles, and protective fire shelters.
- **Respiratory protection** Until very recently, the accepted form of respiratory protection has been a cotton bandana or dust mask worn over the nose and mouth. However, studies have shown that these items do not provide sufficient protection. Beginning in 2011, National Institute for Occupational Safety and Health (NIOSH) certified and NFPA® approved air purifying respirators (APR) and powered air purifying respirators (PAPR) will be available for wildland fire fighting.



Figure 6.17 A fire shelter reflects the heat of a fire away from the firefighter while in use.

• Chain saw protection — Chaps, leggings, or protective trousers made of ballistic nylon fibers that protect the legs (Figure 6.18). According to one source, leg injuries account for a significant number of all chain saw injuries.

Because wildland protective garments will not protect you from extreme heat, you should never wear underclothing made of synthetic materials, such as nylon or polyester, when fighting a wildland fire. These materials melt when heated and can stick to your skin, causing serious burns.

WARNING Wildland personal protective clothing is not designed, certified, or intended for interior structural fire fighting.

Roadway Operations Clothing

Emergency operations along roadways are extremely dangerous for firefighters and emergency responders. No amount of personal protective clothing can prevent injuries when a person is struck by a rapidly moving vehicle. The best protection is to be visible to other motorists and to work behind a barrier formed by your apparatus, as discussed in Chapter 2.

To increase your visibility to oncoming traffic, you should wear traffic vests with retroreflective trim. Retroreflective trim reflects headlight beams, providing visibility at night or in low light situations (**Figure 6.19**). Traffic vests are required by federal law at incidents on federally-funded highways. They should be worn over your PPE if possible, or as soon as the situation has stabilized. Vests are not commonly worn during fire suppression or hazardous materials activities but should be worn at all other times.



Figure 6.18 Protective chaps may limit some injury while using a chain saw.



Figure 6.19 A firefighter wearing a reflective vest is more visible at night than a firefighter wearing standard bunker gear.



Figure 6.20 Protective clothing includes single-use garments.

Emergency Medical Protective Clothing

When providing medical assistance, emergency responders must protect themselves against exposure to infectious bodily fluids and airborne pathogens. To accomplish this, they must wear emergency medical protective clothing. Most structural and wildland protective clothing does not prevent disease transmission, and fire fighting protective clothing is inappropriate because it can contaminate victims through their open wounds.

Emergency medical protective clothing may be either single- or multiple-use garments (Figure 6.20). Single-use garments are disposed of after contact with a patient. Multiple-use garments may be cleaned and reused a specified number of times before disposal. Medical protective clothing must meet NFPA® 1999, *Standard on Protective Clothing for Emergency Medical Operations*. It must also include the following items:

- Utility gloves Not used for patient care but do provide a barrier against bodily fluids, disinfectants, and cleaning solutions.
- Medical examination gloves Gloves that are certified for patient care and provide an effective barrier (against infection) up to the wrist.
- **Eye/face protection device** Faceshield, goggles, safety glasses, or hooded visor that provides limited protection for the eyes and face.
- Facemask A full face device that protects the eyes, face, nose, and mouth.
- Footwear Safety shoes or boots that protect feet and ankles; may be dual certified station/work shoes.
- Footwear cover A single-use item worn over footwear to provide a limited barrier against bodily fluids.
- **Medical garment** Single- or multiple-use clothing that provides a barrier against bodily fluids; may be sleeves, jackets, trousers, gowns, or coveralls that can be worn over a uniform.
- **Medical helmet** Head protection that is designed to provide impact, penetration, and electrical insulation protection while working with a patient in a hazardous area. Helmets must meet ANSI design requirements for Type 1 hard hats.
- **Respiratory protection device** Filter mask that protects the wearer from airborne pathogens.

Special Protective Clothing

Other emergency incident types that require specialized protective clothing include the following:

Technical rescue — Must protect the wearer from physical, thermal, and liquid hazards, as well as infectious diseases. Design criteria are specified in NFPA® 1951, *Standard on Protective Ensembles for Technical Rescue Incidents* (Figure 6.21 a). May be dual certified for emergency medical use as defined by NFPA® 1951 and NFPA® 1999. They may also be chemical, biological, radiological, or nuclear (CBRN) certified. While structural personal protective clothing is sometimes worn for technical rescue operations, it is usually too bulky and heavy. Respiratory protection typically consists of air purifying respirators (APR), SCBAs, or supplied air respirators (SAR).



Figure 6.21 a Technical rescue clothing may include equipment features that are CBRN certified.



Figure 6.21 b Swiftwater rescue equipment safeguards against dangers unique to that environment.



Figure 6.21 c lce rescue clothing serves functions similar to swiftwater clothing but with more thermal insulation. *Courtesy of Iowa Fire Service Training Bureau.*



Figure 6.21 d Personal protective clothing must be chosen to counteract the specific dangers presented by the substances that will be encountered.



Figure 6.21 e Proximity protective clothing reflects radiant heat.

- Standing/Swift Water rescue A full-body wet suit that is buoyant, thermallyinsulated, and abrasion/puncture-resistant (Figure 6.21 b). A rescue helmet is also part of the required ensemble. In addition, a U.S. Coast Guard (USCG) approved personal floatation device (PFD) must be worn in rivers, streams, and lakes, and along shorelines and coastlines.
- Ice rescue Similar to the full-body dry suit that may be used in water rescue, but with more thermal insulation (Figure 6.21 c). USCG PFDs are mandatory, and some models have watertight hoods, integrated gloves, and attachable boots.

- Hazardous materials Varying types include high-temperature protective clothing and chemical-protective clothing (CPC) that protects against splashes and vapor (Figure 6.21 d).
- Chemical, biological, radiological, and nuclear (CBRN) CBRN suits protect against these hazard types during accidents and terrorist incidents. They must adhere to NFPA® 1994, Standard on Protective Ensembles for First Responders To CBRN Terrorism Incidents. NFPA® 1971 also establishes optional design requirements for structural and proximity ensembles that are certified for CBRN incidents. These ensembles must carry the appropriate CBRN label.
- **Proximity fire fighting protective clothing** Similar to structural protective clothing but with an aluminized outer shell on the coat, trousers, gloves, and helmet shroud (**Figure 6.21 e**). This outer shell is designed to reflect high levels of radiant heat and protect against direct flame contact. Must be resistant to water, impact from sharp objects, and electrical shock. Proximity PPE may be used in some hazardous materials operations.

Station/Work Uniforms

Although station and work uniforms look different between jurisdictions, they are all intended to perform two functions. First, they identify the wearer as a member of the organization. Second, the uniform provides a layer of protection against direct flame contact. For this reason, clothing made of non-fire resistant synthetic materials should not be worn while on duty or under your PPE.

All firefighter station and work uniforms should meet the requirements set forth in NFPA® 1975, *Standard on Station/Work Uniforms for Emergency Services*. The purpose of the standard is to provide minimum requirements for work wear that is functional, will not contribute to firefighter injury, and will not reduce the effectiveness of outer personal protective clothing. Garments addressed in this standard include trousers, shirts, jackets, and coveralls, but not underwear. Underwear made of 100 percent cotton is recommended, because synthetic materials melt when heated and can stick to your skin, causing serious burns.

Clothing certified to meet NFPA® 1975 requirements will have a permanently attached label stating that certification (Figures 6.22 a and b). Note that while this clothing is designed to be fire resistant, it is not designed to be worn for fire fighting operations. Structural fire fighting protective clothing must always be worn over these garments when you are engaged in structural fire fighting activities. Wildland protective clothing, depending on design and local protocols, may be worn over station/work uniforms or directly over undergarments. Some station/work uniforms are dual certified as both work uniforms and wildland protective clothing. Dual certified uniforms will always carry the appropriate certification labels.

In many fire departments, safety shoes or boots are part of the station/work uniform. They are required footwear while conducting inspections or doing work around the station. Safety shoes or boots usually have steel toes, puncture-resistant soles, or special inserts. However, footwear used for station duties should not be worn during emergency operations because they might then contaminate living quarters with potentially hazardous substances.

Uniforms can be contaminated/soiled following any emergency response. Therefore, they should not be taken home or washed in personal washing machines or at public laundromats. Contaminated uniforms must be laundered at the fire station or by a contractor.





Figure 6.22 b Clothing that adheres to NFPA® 1975 should be labeled as such.

Figure 6.22 a Uniforms worn in a station must conform to NFPA® 1975 because they will serve as a layer of protection under PPE.

Care of Personal Protective Clothing

Your personal protective clothing is your primary barrier protecting you from injury and illness. However, it can also cause injury or illness if it is not properly maintained. Hydrocarbon contamination will reduce the fire resistance of your PPE (**Figure 6.23**). Chemicals, oils, and petroleum products in or on the outer shell can ignite when exposed to fire. Some contaminants can reduce the effectiveness of retroreflective trim, and soot can obscure its visibility. Hydrocarbons, body fluids, and toxins that contaminate PPE can be inhaled, ingested, or absorbed, causing serious and sometimes fatal illness.

You are responsible for the inspection, cleaning, and condition of the PPE assigned to you. Procedures for the care of your PPE are found in your department's SOPs, the manufacturer's instructions, and NFPA® 1851, *Standard on Selection, Care, and Maintenance of Protective Ensembles for Structural Fire Fighting and Proximity Fire Fighting.*

Inspecting

You should inspect your PPE at the beginning of your work shift, after every use, after washing, repair, decontamination, and on a periodic basis, such as weekly or monthly. An annual inspection should be made by a member of your department who is trained in advanced inspection requirements, such as the department's Health and Safety Officer (HSO).



Figure 6.23 Contamination of protective equipment can directly cause health risks and impair the effectiveness of the PPE.



Figure 6.24 A heat- and smokedamaged faceshield is useless on the fireground and should be replaced before operations.

Conditions that you should look for during a routine inspection include:

- Soiling
- Contamination
- Missing or damaged hardware and closure systems
- Physical damage including rips, tears, and damaged stitching on seams
- Wear due to friction under arms, in the crotch, and at knee and elbow joints
- Thermal damage, including charring, melting, discoloration, and burn holes
- Shrinkage
- Damaged or missing retroreflective trim or reinforcing trim
- Loss of reflectivity of shell on proximity equipment
- Cracks, melting, abrasions, or dents in helmet shell
- Missing or damaged faceshield or hardware (Figure 6.24)
- Missing or damaged earflaps or neck shroud
- Loss of watertight integrity in footwear
- Damage to or faulty installation of drag rescue device (DRD)

If your protective clothing requires only routine cleaning that will not cause the item to be removed from service, you should perform that cleaning yourself. If you ever determine that your PPE requires advanced cleaning or decontamination, repairs, or replacement, report this to your supervisor immediately.



Cleaning

NFPA® 1851 defines four types of cleaning for personal protective clothing:

- Routine cleaning
- Advanced cleaning
- Specialized cleaning
- Contract cleaning

Types of cleaning are determined by the amount and type of contamination and whether the equipment must be removed from service to perform the cleaning. Many fire departments provide spare sets of PPE to replace units removed from service for cleaning, decontamination, or repairs.

Routine cleaning. Routine cleaning does not require that the clothing be removed from service (Figure 6.25). At an incident scene, the process for routine cleaning includes:

- Brushing off loose debris with a broom or soft bristle brush
- Using a gentle spray of water to rinse off debris and soil



Figure 6.25 Maintain the good order of equipment by keeping it clean.

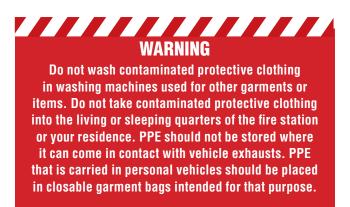
To remove heavy soil, cleaning should be performed by hand in a utility sink, in the designated cleaning area at the fire station. Whether you are at the scene or in the station, always follow the manufacturer's recommendations and wear appropriate gloves and eye protection.

Advanced cleaning. Personnel trained in the care and cleaning of protective clothing should perform advanced cleaning. A washing machine dedicated to cleaning protective clothing that is designed to handle heavy loads should be used.



Specialized cleaning. Required when clothing is contaminated with hazardous materials or body fluids that cannot be removed by routine or advanced cleaning. May be performed by a trained member of the department or an outside contractor. Clothing that is too contaminated to be cleaned must be removed from service and destroyed.

Contract cleaning. Specialized cleaning performed by the manufacturer, its representative, or a certified vendor. Typically removes accumulated grime or contaminants. Some contractors provide replacement PPE while clothing is being cleaned.



Repairing

Damaged protective clothing must be repaired *immediately*, either by the manufacturer, an approved repair facility, or a trained member of the department. Clothing damaged beyond repair must be removed from service and destroyed. Some damaged clothing may be marked for training only and used in non-live fire training.

Safety Considerations for Personal Protective Equipment

PPE is designed to create a protective barrier between you and your work environment. However, this barrier can also isolate you, preventing you from being aware of important environmental changes and making you overconfident of your own safety.

Keep in mind these important safety considerations that relate to your personal protective equipment:

- Always consider the design and purpose of your protective clothing, and be especially aware of each garment's limitations.
- Moisture in the shell and liner material will conduct heat rapidly, resulting in serious steam burns. Always ensure that the garment is dry before wearing it into a fire.
- PPE insulates you from the heat of a fire. This will protect your life, but it will also delay your awareness of temperature increases.
- Never wear protective clothing that does not fit because it will provide reduced protection. Tight clothing will not close properly, leaving a gap. Loose clothing can hinder mobility and dexterity by bunching up at shoulders, elbows, and knees. It can also snag on debris, create a tripping hazard, absorb contaminants, and reduce thermal protection.
- Make sure that the overlap between coat and trousers is a minimum of 2 inches (50 mm) at the waist when you bend over to a 90° angle (Figure 6.26).
- Thermal burns may occur at compression points where the garment layers are pressed together, such as under SCBA shoulder harness, along sleeves in contact with hoselines, and on knees when kneeling on hot debris and embers.
- Radiant heat can rapidly penetrate protective clothing, causing serious burns. If you feel thermal radiant burns developing, withdraw from the area immediately.
- Prolonged exposure to hot environments will cause your body to sweat in order to cool itself. However, the protective clothing liner will retain the moisture produced by sweating, which may cause heat stress or burns. When you feel the symptoms of heat exhaustion, including weakness, dizziness, rapid pulse, or headache, move to a cool, safe area, remove your PPE, and follow established rehabilitation procedures.
- Your PPE is designed to protect you, but it is not designed to protect against extreme fire conditions such as backdraft, flashover, or other extreme fire behavior.



longer the exposure and the higher the temperature. The the greater the severity of a burn. First degree burns start when skin temperature reaches 118° F (47.8° C). Second degree burns start at 131° F (55° C), and third degree burns start at 152° F (66.7° C).



Figure 6.26 A protective coat must overlap the trousers by at least 2 inches (50 mm) no matter which position the firefighter holds during operations.



Figure 6.27 Repair work should be assumed to generate particles that must be kept from contact with skin, eyes, and respiration.

Respiratory Protection

The case history at the beginning of this chapter illustrates how inhaling smoke and other products of combustion poses short-term, long-term, and even fatal health hazards. Wearing appropriate respiratory protection is the most effective way to protect your health. Operations requiring respiratory protection include:

- Structural and wildland fires, which produce smoke and other products of combustion
- Medical responses, which may expose you to airborne pathogens
- Confined space search, rescue, and recovery, which may take place in toxic or low oxygen atmospheres
- Repair work that generates fine particulates such as dust, paint, or metal shavings (Figure 6.27).

Always wear respiratory protection equipment that is appropriate for the type of hazard you are facing. Be sure to use equipment properly so that you are not exposed to **respiratory hazards**.

Respiratory Hazards

Common respiratory hazards include:

- Oxygen deficiency
- Elevated temperatures
- Particulate contaminants
- Gases and vapors
- Airborne pathogens

Respiratory Hazards — Exposure to conditions that create a hazard to the respiratory system, including products of combustion, toxic gases, and superheated or oxygendeficient atmospheres.

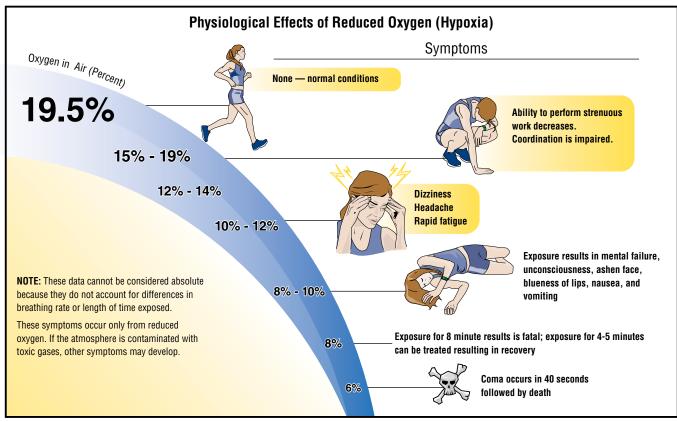


Figure 6.28 Oxygen deficiency has increasingly severe effects depending on the level of reduction and the amount of time it is endured.

Respiratory hazards are often found in situations that produce immediate, irreversible, and debilitating effects on a person's health and may result in death. NFPA® 1500 and OSHA classify these situations as immediately dangerous to life and health (IDLH). Prior to entering any structure or area that is or may be IDLH, you must don the correct level of personal protective clothing and respiratory protection.

Oxygen Deficiency

Both NFPA® and OSHA define an **oxygen-deficient atmosphere** as one containing less than 19.5 percent oxygen. When oxygen concentrations are below 18 percent, the human body responds by increasing its respiratory rate. As less oxygen reaches body tissues **hypoxia** occurs. The physiological effects of hypoxia are illustrated in **Figure 6.28**.

Combustion is the most common cause of oxygen-deficient atmospheres. It consumes oxygen and produces toxic gases, which either physically displace oxygen or dilute its concentration. Oxygen-deficient atmospheres also occur in confined spaces such as sewers, chemical storage tanks, grain bins, or underground caverns. They are also found in rooms or compartments where carbon dioxide (CO_2) total-flooding extinguishing systems have discharged.

Some fire departments are equipped with instruments to monitor atmospheres and measure oxygen levels or the presence of toxic gases. Where monitoring is not possible or monitor readings are questionable, SCBA or SAR must always be worn.

Oxygen-Deficient Atmosphere — Atmosphere containing less than the normal 19.5 percent oxygen. At least 16 percent oxygen is needed to produce flames or sustain human life.

Hypoxia — Potentially fatal condition caused by lack of oxygen.

Elevated Temperatures

Exposure to superheated air can damage the respiratory tract. The damage can be much worse when the air is moist. Excessive heat inhaled quickly into the lungs can cause a serious decrease in blood pressure and failure of the circulatory system. Inhaling superheated gases can cause **pulmonary edema** which can cause death from **asphyxiation**. The tissue damage from inhaling hot air is not immediately reversible by introducing fresh, cool air. Prompt medical treatment is required.



Particulate Contaminants

Particulate contaminants are small particles that may be suspended in the air and are harmful to the respiratory system. Sources of these particulates include:

- Vehicle exhaust emissions
- Chemical reactions
- Heated metals or metal compounds
- Combustion

According to medical studies, exposure to particulate contaminants causes asthma, lung cancer, cardiovascular disease, and premature death. Smaller particulates are especially dangerous, because particulates bigger than 1 micrometer are filtered by the nasal membranes and do not enter the lungs.

Particulate contaminants may be encountered during the following situations:

- Wildland fires
- Welding and metal cutting operations
- Operation of fire apparatus and small engines (Figure 6.29)
- Operations following an explosion or building collapse
- Structural fires, especially during the overhaul phase



Figure 6.29 Diesel exhaust carries small particulates as well as other contaminants that are known to cause health risks.

Pulmonary Edema — Accumulation of fluids in the lungs.

Asphyxiation — Fatal condition caused by severe oxygen deficiency and an excess of carbon monoxide and/or other gases in the blood.

Particulate — Very small particle of solid material, such as dust, that is suspended in the atmosphere.



Figure 6.30 a APR units filter the working environment and capture airborne particles.



Figure 6.30 b PAPR units include a headpiece, a breathing tube, a battery, and an air blower.

Air-Purifying Respirator (APR) — Respirator that removes contaminants by passing ambient air through a filter, cartridge, or canister; may have a full or partial facepiece.

Powered Air-Purifying Respirator (PAPR) — Motorized respirator that uses a filter to clean surrounding air, then delivers it to the wearer to breathe; typically includes a headpiece, breathing tube, and a blower/battery box that is worn on the belt.

Gas — Compressible substance, with no specific volume, that tends to assume the shape of the container. Molecules move about most rapidly in this state.

Vapor — Gaseous form of a substance that is normally in a solid or liquid state at room temperature and pressure; formed by evaporation from a liquid or sublimation from a solid. **Air-purifying respirators (APRs)** and **powered air-purifying respirators** (PAPRs) are generally sufficient to protect you from particulate contaminants (Figures 6.30 a and b). Cartridge and canister type APR/PAPRs have half or full facepiece units with replaceable filter elements that capture the particulates. APR/PAPRs are approved for wildland fire fighting but do not protect against toxic gases or heated or oxygen-deficient atmospheres.

Gases and Vapors

Gases and **vapors** may be present at both fire and nonfire incidents. Gases exist at standard temperature and pressure, while vapors result from temperature or pressure changes that affect a solid or liquid. For example, natural gas is found in a gaseous state within the earth, while steam is a vapor created when water is heated.

Gases and vapors can be inhaled, ingested, or absorbed into the body, resulting in illnesses and death. Exposure may cause:

- Cancer
- Cardiovascular disease
- Thyroid damage
- Respiratory problems
- Eye irritation

Fire gases and vapors. Harmful gases and vapors created by combustion include:

- Carbon monoxide
- Carbon dioxide

- Hydrogen cyanide
- Hydrogen chloride
- Hydrogen sulfide
- Nitrous gases
- Phosgene
- Sulfur dioxide
- Ammonia
- Formaldehyde

Of these, carbon monoxide (CO) and hydrogen cyanide (HCN) are responsible for the majority of fire-related fatalities. Carbon monoxide is a colorless, odorless gas that is present in virtually every fire. It is released when an organic material burns in an atmosphere with a limited supply of oxygen.

Carbon monoxide poisoning is a sometimes lethal condition in which carbon monoxide molecules attach to hemoglobin, decreasing the blood's ability to carry oxygen. Carbon monoxide combines with hemoglobin about 200 times more effectively than oxygen does. The carbon monoxide does not act on the body, but excludes oxygen from the blood, leading to hypoxia of the brain and tissues, followed by death if the process is not reversed. **Table 6.1** illustrates the effects of CO on humans.

Hydrogen cyanide is produced by the incomplete combustion of substances containing nitrogen and carbon, such as natural fibers, resins, synthetic polymers, and synthetic rubber. These materials are found in upholstered furniture, bedding, insulation, carpets, and other common building materials. HCN is also released during off-gassing as an object is heated. It may also be found in unexpected places, such as vehicle fires, where new insulation materials give off high amounts of gases and cause fires to last longer.

HCN can be inhaled, ingested, or absorbed into the body, where it then targets the heart and brain. Inhaled HCN enters the blood stream and prevents the blood cells from using oxygen properly, killing the cell. The effects of HCN depend on the concentration, length, and type of exposure. Large amounts, high concentrations, and lengthy exposures are more likely to cause severe effects, including permanent heart and brain damage or death. HCN is 35 times more toxic than CO. **Table 6.2, p. 286** illustrates the effects of HCN on the human body.

Nonfire gases and vapors. Hazardous materials can produce a potentially hazardous gases and vapors in nonfire emergencies, such as the following:

- Incidents involving industrial, commercial, or warehouse occupancies
- Spills resulting from transportation accidents
- Leaks from storage containers or pipelines

Table 6.1Toxic Effects of Carbon Monoxide

Carbon Monoxide (CO) (ppm*)	Carbon Monoxide (CO) in Air (Percent)	Symptoms
100	0.01	No symptoms — no damage
200	0.02	Mild headache; few other symptoms
400	0.04	Headache after 1 to 2 hours
800	0.08	Headache after 45 minutes; nausea, collapse, and unconsciousness after 2 hours
1,000	0.10	Dangerous — unconsciousness after 1 hour
1,600	0.16	Headache, dizziness, nausea after 20 minutes
3,200	0.32	Headache, dizziness, nausea after 5 to 10 minutes; unconscious- ness after 30 minutes
6,400	0.64	Headache, dizziness, nausea after 1 to 2 minutes; unconscious- ness after 10 to 15 minutes
12,800	1.28	Immediate uncon- sciousness; danger of death in 1 to 3 minutes

*ppm — parts per million

Table 6.2Lethal Exposure Times and Concentrations of
Hydrogen Cyanide (HCN) on Humans

Exposure Time	Concentration in parts per million (ppm)
1 minute	3,404 ppm
6 to 8 minutes	270 ppm
10 minutes	181 ppm
30 minutes	135 ppm
> 29 minutes	20 to 40 ppm

Symptoms Indicating Exposure to Hydrogen Cyanide (HCN)

Initial	Initial	Progressive	Final
Concentration	Symptoms	Symptoms	Effect
20 to 40 ppm	Headache, drowsi- ness, vertigo, weak and rapid pulse, deep and rapid breathing, a bright-red color in the face, nausea, and vomiting	Convulsions, dilated pupils, clammy skin, a weaker and more rapid pulse and slower, slow, or irregular heartbeat, falling body tempera- ture, blue color to lips, face, and extremities, coma, and shallow breathing	Death

At any haz mat incident, always remain at a safe distance (upwind, uphill, upstream) until a risk analysis has been completed. The surrounding atmosphere at these incidents should always be considered dangerous, so SCBAs must be worn until air monitoring demonstrates that the atmosphere is safe.

Hazardous nonfire gases and vapors are always a possibility at transportation incidents and in storage and manufacturing facilities. Common gas and vapor types include:

- Carbon Dioxide Also produced by fire suppression systems
- Ammonia Also produced by air conditioning and cooling systems
- Sulfur Dioxide Also produced by air conditioning and cooling systems
- **Chlorine** Also found in water treatment facilities, water parks, and swimming pools
- Pesticides Also found in commercial outlets, farms, nurseries, and residences

Toxic gases may also be found in sewers, storm drains, caves, trenches, storage tanks, tank cars, bins, and other confined spaces. Even when toxic gases are not present, the atmosphere in these areas may be oxygen deficient and potentially deadly. Search, rescue, and recovery in these areas require the use of SCBAs and SARs.

Airborne Pathogens

Airborne pathogens are disease-causing microorganisms (viruses, bacteria, or fungi) that are suspended in the air. They may be encountered when assisting victims during medical responses, vehicle extrications, rescue and recovery operations, and terrorist attacks. They cause infection after being inhaled or directly contacted.

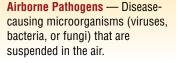
Illnesses that can result from exposure to airborne pathogens include:

- Meningitis
- Influenza
- Methicillin-resistant Staphylococcus aureus (MRSA)
- Pneumonia
- Tuberculosis (TB)
- Severe acute respiratory syndrome (SARS)
- Measles
- Chickenpox
- Smallpox

Protection against airborne pathogens includes high-efficiency particulate air (HEPA) filters, APR/PAPRs, and SCBA/SAR. HEPA filter masks are single-use masks that are certified by NIOSH and designated N95, N99, or N100 (Figure 6.31). Designations indicate the percentage of airborne particles that the masks effectively remove. Note that surgical masks are not approved for use against airborne pathogens. However, they may be used on patients to prevent them from spreading diseases by exhaling, sneezing, or coughing.

Types of Respiratory Protection Equipment

The two categories of respiratory protection equipment are atmosphere-supplying respirators (ASRs) and air-purifying respirators (APRs). ASRs provide breathable air when working in oxygen deficient, toxic, or gas-filled atmospheres, while APRs only filter particulates out of the ambient air. The primary type of respiratory protection that you will use in the fire service is the ASR.



High-Efficiency Particulate Air (HEPA) Filter — Respiratory filter that is certified to remove at least 99.97 % of monodisperse particles of 0.3 micrometers in diameter.



Figure 6.31 A HEPA filter mask removes airborne particles before inhalation.

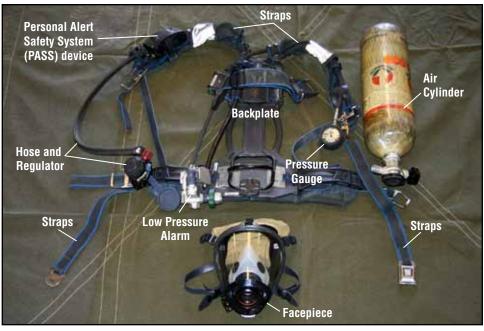


Figure 6.32 a An SCBA unit is intended to support a limited-time engagement in high-intensity operations.

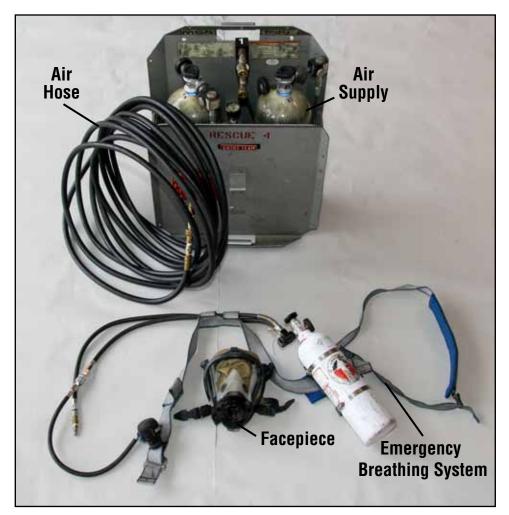


Figure 6.32 b A supplied-air respirator system is intended to support longer engagements under conditions that will not damage the equipment.

Atmosphere-Supplying Respirators (ASRs)

Atmosphere-supplying respirators consist of either SCBA or supplied air respirators (SARs) (Figures 6.32 a and b). SCBAs carry the air in a cylinder, while SARs are connected to a breathing air compressor or portable air supply, providing breathable air for a much longer duration.

SARs are used when the firefighter must be in the hazardous area for a long period of time, and there is no danger that fire may damage the air hose. These types of situations include hazardous materials incidents, confined space rescues, and other technical rescue incidents. They are not used for fire fighting because of the possibility that fire or debris will damage the air-supply hose. They are only used by personnel who are certified in technical rescue functions.

There are two main types of SCBAs: **open-circuit SCBAs**, which use compressed air, and **closed-circuit SCBAs**, which use compressed oxygen (**Figures 6.33 a and b**). In open-circuit SCBA, exhaled air is vented to the outside atmosphere. In closed-circuit SCBA (also known as "rebreather" apparatus), exhaled air stays within the system and is reused. Closed-circuit SCBA are much less common and are mainly used in shipboard operations, extended hazardous materials incidents, some rescue operations, and by industrial fire brigades.

Open-Circuit Self-Contained Breathing Apparatus — SCBA that allows exhaled air to be discharged or vented into the atmosphere.

Closed-Circuit Breathing

Apparatus — SCBA that recycles exhaled air; removes carbon dioxide and restores compressed, chemical, or liquid oxygen. Not approved for fire fighting operations. *Also known as* Oxygen-Breathing Apparatus (OBA) or Oxygen-Generating Apparatus.

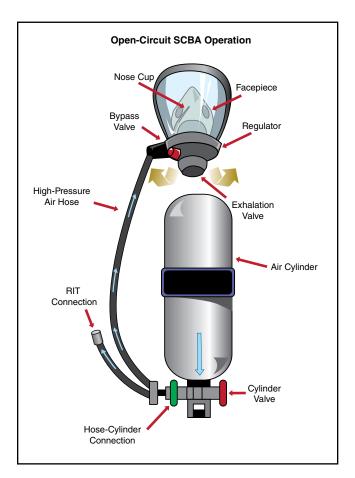


Figure 6.33 a An open-circuit SCBA vents exhaled air to the outside atmosphere.

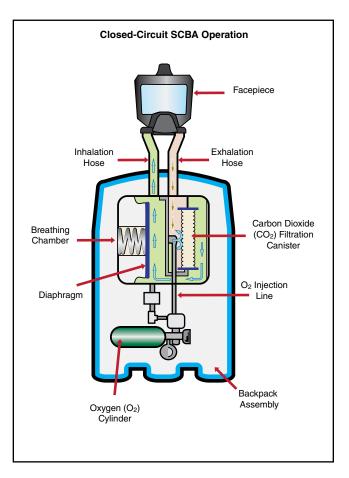


Figure 6.33 b A closed-circuit SCBA reuses exhaled air to allow the user to remain in a hazardous environment for a longer duration.



Figure 6.34 The backplate and harness assembly provide stability to the breathing air cylinder while in use.

Open-circuit SCBA consist of four basic components:

- Backplate and harness assembly
- Air cylinder assembly
- Regulator assembly
- Facepiece assembly

Backplate and harness assembly. This rigid frame with adjustable straps holds the breathing air cylinder on the backplate, and onto the firefighter's back. The straps are designed to stabilize the unit, carry part of its weight, and provide a secure and comfortable fit (**Figure 6.34**). An adjustable waist strap also distributes some of the apparatus' weight to the hips.

Air cylinder assembly. The air cylinder contains breathing air under pressure. It may be constructed of steel, aluminum, aluminum wrapped in fiberglass, or a Kevlar/ carbon composite material. Common cylinder sizes are shown in **Table 6.3**.

Depending on size and construction materials, cylinders weigh from 7.9 pounds (3.6 kg) to 18.9 pounds (8.6 kg). This weight significantly increases physical stress during emergency operations.

The cylinder has a control valve, threaded stem and/or quick-connect fitting, and a pressure gauge attached to one end. When in operation, the control valve is opened fully to emit air into the system. The high-pressure hose attaches to the stem and connects the cylinder to the regulator assembly. The pressure gauge displays an estimate of the amount of air in the cylinder in pounds per square inch (psi) (kilopascal [kPa]).

Table 6.3 Breathing Air Cylinder Capacities			
	Rated Duration	Pressure	Volume
-	30-minute	2,216 psi (15 290 kPa)	45 ft ³ (1 270 L) cylinders
	30-minute	4,500 psi (31 000 kPa)	45 ft ³ (1 270 L) cylinders
	45-minute	3,000 psi (21 000 kPa)	66 ft³ (1 870 L) cylinders
	45-minute	4,500 psi (31 000 kPa)	66 ft³ (1 870 L) cylinders
	60-minute	4,500 psi (31 000 kPa)	87 ft ³ (2 460 L) cylinders

• Rated duration does not indicate the actual amount of time that the cylinder will provide air.

Regulator assembly. Air from the cylinder travels through the high-pressure hose to the regulator assembly. The regulator reduces the high pressure of the cylinder air to slightly above atmospheric pressure and controls airflow to the wearer. When the wearer inhales, a pressure differential is created in the regulator. The apparatus diaphragm moves inward, tilting the admission valve so that low-pressure air can flow into the facepiece. The regulator diaphragm is then held open, which creates the positive pressure. Exhalation moves the diaphragm back to the "closed" position. The regulator may be located on the facepiece, the shoulder harness, or the waist belt harness (Figure 6.35).

Depending on the SCBA model, the regulator will have control valves for normal and emergency operations. These are the mainline valve and the bypass valve. On models equipped with both valves, the mainline valve is locked in the open position during normal operations and the bypass valve is closed. On some SCBA, the bypass valve controls a direct airline from the cylinder in the event that the regulator fails. Once the valves are set in their normal operating position, they should not be changed unless the emergency bypass function is needed. The current generation of regulators have only the bypass valve (**Figure 6.36**).



Figure 6.35 The regulator controls the flow of air to meet the respiratory requirements of the user.

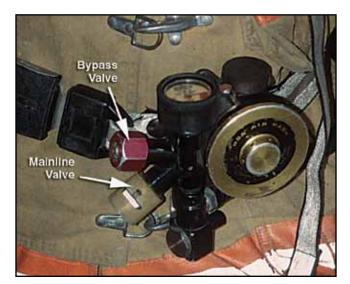


Figure 6.36 The mainline valve and bypass valve on this older belt-mounted regulator are identified by their shape, color, and position.



Figure 6.37 A facepiece assembly that fits snugly provides protection against a series of predictable hazards including heat and large airborne particles.



Figure 6.38 The series of lights in a heads-up display provides a constant reminder of the air pressure in a cylinder. *Courtesy of Arlington (TX) Fire Department. Photograph by Jason Arias.*

Qualitative Fit Test (QLFT) —

Respirator fit test that measures the wearer's response to a test agent, such as irritant smoke or odorous vapor. If the wearer detects the test agent, such as through smell or taste, the respirator fit is inadequate.

Quantitative Fit Test (QNFT) — Fit test in which instruments measure the amount of a test agent that has leaked into the respirator from the ambient atmosphere. If the leakage measures above a pre-set amount, the respirator fit is inadequate. *Facepiece assembly.* The facepiece assembly provides fresh breathing air while protecting the eyes and face from injury. To accomplish these functions, the facepiece must fit tightly to the face. The facepiece assembly consists of (**Figure 6.37**):

- Facepiece frame and lens Made of clear safety plastic and mounted in a flexible rubber facepiece frame. According to NFPA® 1981, all new SCBA facepieces must be equipped with a heads-up display (HUD) (Figure 6.38). This feature displays a series of lights on the inside of the facepiece lens indicating the approximate amount of air remaining in the cylinder.
- Head harness and straps This harness, with adjustable straps, net, or some other arrangement, holds the facepiece snugly against the face.
- Exhalation valve Simple, one-way valve that releases exhaled air without admitting any of the contaminated outside atmosphere.
- Nose cup Deflects exhalations away from the lens, reducing fogging or condensation on the lens.
- **Speaking diaphragm** This mechanical diaphragm permits limited communication by the wearer. It may be replaced by an electronic speaking diaphragm connected to a portable radio.
- **Regulator fitting or hose connection** Permits the regulator or hose to attach to the facepiece frame.

To ensure that the facepiece has a perfect seal, the wearer must be fit-tested to determine the correct fit (**Figure 6.39**). The test must use the same make, model, style, and size of facepiece that will be worn during emergency operations. OSHA currently accepts two types of tests: **qualitative** and **quantitative**. Both tests provide an adequate assessment of a facepiece's ability to maintain a complete seal to the face.

NFPA® 1500 prohibits beards or facial hair that prevents a complete seal between the facepiece and the wearer's face. Wearing eyeglasses is also prohibited if the side frames pass through the seal area. Eyeglass kits are provided with all full facepiece



Figure 6.39 The NFPA® requires that each person wearing a respirator must be fit-tested for his or her own equipment.



Figure 6.40 An end-of-service-time indicator may take the form of a bell that chimes when the air cylinder is nearly depleted.

masks. Both NFPA® 1500 and *Code of Federal Regulations (CFR)* 1910.134 allow firefighters to wear soft contact lenses while using full facepieces if the firefighter has demonstrated successful long-term (at least 6 months) use of contact lenses without any problems.

Additional components. A remote pressure gauge displays the air pressure within the cylinder. It must be mounted in a visible position. Pressure readings are most accurate at or near the upper range of the gauge's rated working pressures. Low pressure is measured less accurately, so the gauge's readings at this low end of the scale may not match the reading on the regulator gauge. When this occurs, assume that the lowest reading is correct. Also, check to make sure that the equipment is in working order before using it again.

Both NFPA® and NIOSH require that two end-of-service-time indicators (ESTI) or redundant low-pressure alarms be installed on all SCBAs (Figure 6.40). The ESTI's alarm warns the user that the system is reaching the end of its air-supply, typically when it reaches 20-25 percent of the cylinder's capacity. The ESTI has both an audible alarm (like a bell, electronic beep, or high-pitched siren) and a flashing light or physical vibration. The alarm cannot be turned off until the air-cylinder valve is closed and the system is bled of all remaining pressure.

All new SCBA are equipped with a rapid intervention crew universal air coupling (RIC UAC) located within 4 inches (101 mm) of the cylinder outlet. This allows any cylinder that is low on air to be transfilled from another cylinder, regardless of its manufacturer (**Figure 6.41**). When the cylinders are connected, the air supply equalizes between them. Older SCBA can be retrofitted with the RIC UAC, but this is not required. Thorough training in the use of this feature is required.

Air-Purifying Respirators (APRs)

Air-purifying respirators (APRs) remove contaminants by passing ambient air through a filter, canister, or cartridge. APRs may have full facepieces that provide a complete seal to the face and protect the eyes, nose, and mouth or half facepieces that provide a complete seal to the lower part of the face and protect the nose and mouth (**Figure 6.42, p. 294**).

Code of Federal Regulations (CFR) — Rules and regulations published by executive agencies of the U.S. federal government. These administrative laws are just as enforceable as statutory laws (known collectively as federal law), which must be passed by Congress.



Figure 6.41 The Universal Air Coupling (UAC) allows an RIC member to connect an air cylinder to the system and transfill the low cylinder. *Courtesy of Kenneth Baum.*



Particulate filters are single-use items that protect the respiratory system from large airborne particulates. They may be used with half or full facepiece masks, and are mounted on one or both sides of the facepiece. When used with a half facepiece mask, eye protection is required.

Particulate filters are regulated by the *Code of Federal Regulations*, specifically Title 42: Public Health, Part 84: Approval of Respiratory Protective Devices. They are divided into nine classes, three levels of filtration (95, 99, and 99.97 percent), and three categories of filter degradation (N, R, and P) that indicate the filter's limitations:

- *N* Not resistant to oil
- **R** Resistant to oil
- *P* Used when oil or non-oil lubricants are present

Particulate filters are used primarily at emergency medical incidents to protect against airborne diseases. They are also appropriate for investigations or inspections involving body recovery; when bird, bat, or rodent excrement is present; at agricultural and industrial accidents; and when working with particulate-producing tools, such as sanders and paint sprayers (**Figure 6.43**).

Limitations of the APR are the limited life of the filters, canisters, and cartridges; the need for constant monitoring of the contaminated atmosphere; and the need for a normal oxygen content of the atmosphere before use. Usage should be restricted to the hazards for which the APR is certified.

APRs should be inspected regularly and cleaned following each use. Filters, canisters, and cartridges should be discarded following use and when they have passed their end of service life date.

NIOSH-certified APRs do not have ESTIs like the ones found on SCBA. Instead, the canisters and cartridges have visual ESTIs only. These indicators show when the air cleanser has become totally saturated and is no longer providing breathable air. Indicators should be checked visually before entering contaminated atmospheres and periodically while wearing the APR. If it appears that the canister or cartridge is reaching its saturation level, exit the area and replace the canister or cartridge.

Other clues or symptoms that the canister, cartridge, or filter is losing effectiveness are time, taste, smell, and resistance-to-breathing indicators. You should estimate

Figure 6.42 Full- and halfface APRs use a filter as a barrier against particulate contamination in the ambient air.

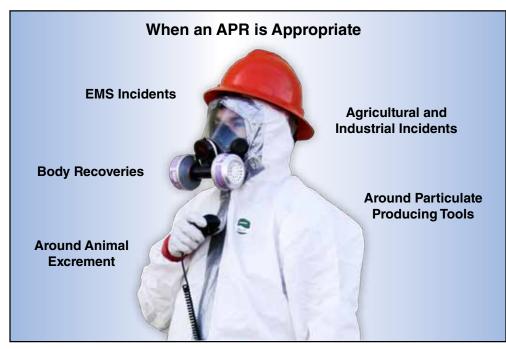


Figure 6.43 Particulate filters must include an end of service time indicator (ESTI).

the amount of time that the work in the contaminated area will take and compare it to the manufacturer's estimated life expectancy for the canister, cartridge, or filter. When the estimated time approaches, exit the area. If you can smell or taste the contaminant, the unit is no longer providing the proper level of protection. Finally, filters that have reached their saturation level cause resistance in the breathing process, causing your breathing to become labored. This is an indication that you must leave the work area before removing the facepiece.

Respiratory Protection Limitations

Although they protect you from a variety of hazards, all respiratory protection equipment has limitations. You must be aware of these limitations if you are going to operate safely and effectively in hazardous atmospheres. Limitations may be created by the wearer or by the equipment itself.

Wearer Limitations

The limitations that you have the greatest control over are those created by you, the wearer. These limitations include:

- Lack of physical condition If you are not in good physical condition or if you are overweight, you may deplete your air supply rapidly.
- Lack of agility If you not sufficiently agile, the weight and restriction of the equipment will make you less so, thus making it difficult to accomplish your assigned tasks.
- **Inadequate pulmonary capacity** You must have sufficient lung capacity to inhale and exhale sufficient air while wearing respiratory protection equipment.
- Weakened cardiovascular ability You must have a strong enough heart to prevent heart attacks, strokes, or other related problems while performing strenuous activity.



Safety Alert

In July 2012, during the production of Essentials 6th edition, the NFPA® issued a safety alert for SCBA facepieces.

See Page 335 for this alert.

- **Psychological limitations** You must be able to overcome stress, fear, and feelings of claustrophobia while wearing respiratory protection equipment.
- Unique facial features The shape and contour of the face can affect the ability to get a complete facepiece-to-face seal. Weight loss or gain can alter the facepiece seal.

These limitations can be offset through constant training with each type of respiratory protection equipment you use, periodic medical evaluations, and proper fit testing of respiratory protection facepieces. Training will make you more confident and more effective while wearing respiratory protection equipment.

Equipment Limitations

Both ASR and APR/PAPR units have limitations, including:

- Limited visibility The full facepiece can reduce peripheral vision, while facepiece fogging can reduce overall vision.
- **Decreased ability to communicate** The facepiece can seriously hinder voice communication unless it has built-in voice amplification or a microphone connection.
- **Decreased endurance** The weight of SCBA units, averaging between 25 and 35 pounds (11 kg and 16 kg), makes you tire more quickly.
- **Decreased mobility** The increase in weight and the restrictions caused by the harness straps can reduce your mobility.
- **Poor condition of apparatus** Minor leaks and poor valve and regulator adjustments can result in excess air loss.
- Low air cylinder pressure If the cylinder is not filled to capacity, the amount of working time is reduced proportionately.

You have some control over these limitations through frequent and proper inspections, care, and maintenance. Training with the units that you will use can also help you overcome the weight and mobility factors.

Storing Respiratory Protection Equipment

Methods of storing SCBA vary from department to department, but each department should store equipment so that it can be quickly and easily donned (**Figure 6.44**). Respiratory equipment should also be protected from contamination, temperature changes, and ultraviolet light, all of which can cause damage. Storage for specific pieces of equipment (such as APR/PAPRs) depends on their size, available storage compartments on the apparatus, and the manufacturer's instructions.

SCBA can be placed on the apparatus in seat, side, and compartment mounts, or stored in carrying cases. If placed in seat mounts, the SCBA should be arranged so that it may be donned without the firefighter having to remove the seat belt.





Figure 6.44 Equipment is secured so it may be donned easily from its storage hook.

Donning and Doffing Protective Breathing Apparatus

Several methods can be used to don an SCBA, depending on how it is stored. The most common include the over-the-head method, the coat method, donning from a seat, and donning from a side/rear external mount or backup mount. Each donning method requires different steps.

Different brands and models also require different steps for securing the SCBA to the wearer. Because the wide variety of SCBA makes it impossible to list these procedures for each manufacturer's model, this section provides only a general description of the four different donning techniques. Make sure to follow the manufacturer's instructions and local SOPs for the particular SCBA assigned to you.

General Donning Considerations

Multiple safety checks must always be made before donning the SCBA. Firefighters with daily shift changes should perform these checks at the beginning of their shifts, then return the SCBA to the apparatus-mounted storage rack or the storage case. Departments that are unable to make daily inspections should perform the following checks immediately prior to donning the SCBA, regardless of how it is stored:

• Check the air cylinder gauge to make sure the cylinder is full. NFPA® 1852, *Standard* on Selection, Care, and Maintenance of Open-Circuit Self-Contained Breathing Apparatus (SCBA), recommends no less than 90 percent of cylinder capacity (Figure 6.45, p. 298).



Figure 6.45 Confirm the fill level and proper function of an air cylinder.



Figure 6.46 A remote pressure gauge should be confirmed against the cylinder gauge and read within recommended parameters.

- Check the remote gauge and cylinder gauge to ensure that they read within the manufacturer's recommended limits (Figure 6.46).
- Check the harness assembly and facepiece to ensure that all straps are fully extended.
- Operate all valves to ensure that they function properly and are left in the correct position.
- Test the low-pressure alarm.
- Test the PASS device to ensure that it is working.
- Check all battery-powered functions.

Donning an Unmounted SCBA

SCBA stored in cases can be donned using the over-the-head method and the coat method. In both methods, the SCBA must be positioned on the ground in front of the firefighter (either in or out of the case) with all straps extended, ready to don. The steps for donning structural PPE are described in **Skill Sheet 6-I-1**. The steps for donning SCBA using the over-the-head method are described in **Skill Sheet 6-I-2**, and the steps for the coat method are described in **Skill Sheet 6-I-3**.



Figure 6.47 Seat-mounted SCBA allow firefighters to don gear while en route. *Courtesy of Kenneth Baum.*

Donning from a Seat Mount

Seat-mounted SCBA permit firefighters to don the unit while seated in the apparatus. But this method should be used only if the firefighter can do so without removing the apparatus seat belt (**Figure 6.47**).

NFPA® 1901, *Standard for Automotive Fire Apparatus*, requires that the SCBA be held in place by a mechanical latching device. There are a wide variety of mounting brackets available that meet this requirement. The facepiece should be stored in a drawstring or other quick-opening bag, or in a pouch on your protective coat. This will keep it clean and protect it from dust and scratches. (**NOTE:** Do not keep the facepiece connected to the regulator during storage. These parts must be kept separate, in order to check for proper facepiece seal.) The steps for donning SCBA from a seat mount are described in **Skill Sheet 6-I-4**.



Figure 6.48 Externallymounted SCBA units contained in protective covers can be donned quickly. *Courtesy of Ron Bogardus.*



The air cylinder's position in the seat back should match the proper wearing position for the firefighter. The visible seat-mounted SCBA reminds and even encourages personnel to check the equipment more frequently. Because it is exposed, safety checks can also be made more conveniently.

When exiting the apparatus, do so carefully because the extra weight of the SCBA on your back can make slips and falls more likely. Be sure to adjust all straps for a snug and comfortable fit.

Donning from a Side or Rear External Mount

Side- or rear-mounted SCBA are mounted on the exterior of the apparatus (**Figure 6.48**). Although this type of mount does not permit donning en route and requires more time for donning than seat-mounted SCBA, it reduces the chances of slips and falls. It is also faster than donning an SCBA stored in a carrying case, because you do not have to remove the case from the apparatus, place it on the ground, open the case, and pick up the unit. One potential disadvantage of exterior mounting is that the SCBA can be exposed to weather and other physical hazards. However, waterproof covers will minimize the risk of damage.

If SCBA are mounted at the correct height, firefighters can don them with little effort. Having the mount near the running boards or tailboard allows the firefighter to don the equipment while sitting on the running board or tailboard. The donning steps are similar to those for seat-mounted SCBA.

Donning from a Backup Mount

Backup mounts located inside a compartment are protected from the weather and provide the same advantages as side- or rear-mounted equipment. However, some compartment doors may interfere with a firefighter donning SCBA. Other compartments may be located too high on the apparatus, making donning more difficult.

One type of compartment mount has a telescoping frame that extends the equipment outward (Figure 6.49). Some of these also telescope upward or downward so that a standing firefighter can don the SCBA more quickly.

The backup mount provides quick access to SCBA (some high-mounted SCBA must be removed from the vehicle and donned using the over-the-head or coat method). The procedure for donning SCBA using the backup method is similar to the method used for seat-mounted SCBA.



Figure 6.49 SCBA may be mounted on a frame that moves the equipment from an inaccessible storage area to the proper height for easy donning.



Figure 6.50 By pulling facepiece straps simultaneously, a snug fit can be maintained.



Figure 6.51 The interface between the hood and facepiece should reinforce the unimpaired contact between skin and the facepiece seals.

Donning the Facepiece

Most SCBA facepieces are donned using very similar steps. One important difference is that some facepieces use a rubber harness, while others use a mesh skullcap. Both have adjustable straps, although some models have more straps than others.

Another difference is the location of the regulator. It may be attached to the facepiece or mounted on the waist belt or shoulder harness. The shape and size of facepiece lenses may also differ. Despite these differences, donning procedures for facepieces are essentially the same.

The following are general considerations for donning all SCBA facepieces:

- All straps should be fully extended.
- No hair should come between the skin and the facepiece sealing surface.
- The chin should be centered in the chin cup and the harness centered at the rear of the head.
- Facepiece straps should be tightened by pulling opposing straps evenly and simultaneously to the rear (**Figure 6.50**). Pulling the straps outward, to the sides, may damage them and prevent proper engagement with the adjusting buckles. Tighten the lower straps first, then the temple straps, and finally the top strap if there is one.
- Always check that the facepiece is completely sealed to the face, the exhalation valve is functioning, and all connections are secure. If there is a donning mode switch, check that it is in the proper position.
- The protective hood must be worn over the facepiece harness or straps. All exposed skin must be covered and vision must not be obscured. No portion of the hood should be located between the facepiece and the face (Figure 6.51).
- The helmet should be worn with the chin strap secured. Helmets equipped with a ratchet adjustment should be adjusted so that the helmet fits properly (Figure 6.52).



Figure 6.52 A ratchet screw on a helmet allows a firefighter to fine tune the fit of the helmet.

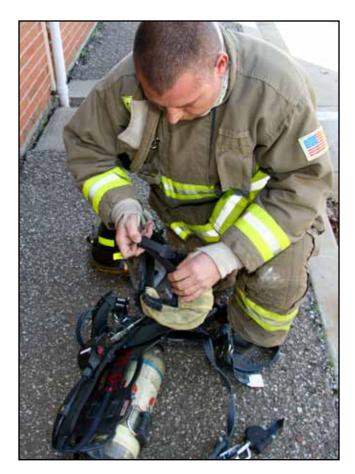


Figure 6.53 After removing a facepiece, extending all straps will help make it ready for the next use.

Doffing Protective Breathing Apparatus

Doffing (removal) techniques differ for the different types of SCBA. However, the following actions apply when doffing any brand or model:

- Make sure you are out of the contaminated area and that the SCBA is no longer required.
- Discontinue the flow of air from the regulator to the facepiece.
- Disconnect the regulator from the facepiece.
- Remove the protective hood, or pull it down around your neck.
- Remove the facepiece by loosening the straps and lifting it from your chin.
- Remove the backpack assembly while protecting the regulator.
- Close the cylinder valve.
- Relieve pressure from the regulator according to the manufacturer's instructions.
- Turn off the PASS device.
- Extend all facepiece and harness straps (Figure 6.53).
- Check air pressure to determine if the air cylinder needs to be refilled or replaced.
- Clean and disinfect the facepiece.
- Clean the SCBA backplate and harness if necessary.
- Secure the complete unit in its case, seat bracket, or storage bracket.

The steps for doffing personal protective equipment and SCBA and preparing them for use are described in **Skill Sheet 6-I-5**.

Inspection and Maintenance of Protective Breathing Apparatus

The frequency of SCBA inspections is established by NFPA® 1852. Firefighters inspect their SCBA on a schedule determined by their department and based on NFPA®, OSHA, and the manufacturer's requirements. Inspections are typically performed daily, weekly, or whenever firefighters report for duty. However, the period between inspections must not exceed one week. Qualified SCBA repair technicians must inspect the units annually and after any repairs have been completed.

Protective Breathing Apparatus Inspections and Care

Your SCBA requires ongoing inspection and maintenance to protect you properly. You must clean and inspect it after each use, at the beginning of every duty shift, and every week. If repairs are necessary, report this immediately. Extensive repairs and cleaning may require that the unit be taken out of service and replaced by a reserve unit. The steps for inspecting an SCBA are described in **Skill Sheet 6-I-6**.

Inspections

The daily/weekly inspection is divided according to the SCBA components and includes the following:

Facepiece.

- Inspect the facepiece frame for deterioration, dirt, cracks, tears, and holes.
- Inspect head-harness buckles, straps, and webbing for wear, breaks, or loss of elasticity.
- Inspect the lens for scratches, abrasions, holes, cracks, or heat damage.
- Inspect the HUD for proper operation.
- Inspect the lens for a proper seal with the facepiece frame.
- Inspect the valve seat of the exhalation valve.
- Inspect the springs and covers to ensure cleanliness and ease of operation.
- Inspect the regulator and hose connection points for cleanliness, damage, and proper operation (Figure 6.54, p. 304).
- Inspect the speaking diaphragm for cleanliness and damage.

Backplate and harness assembly.

- Inspect the harness straps and backplate for abrasions, cuts, tears, or heat or chemical-induced damage (Figure 6.55, p. 304).
- Ensure all the buckles, fasteners, and adjustments operate properly.
- Ensure the harness straps are fully extended.
- Inspect the cylinder retention system for proper operation and damage.
- Ensure the cylinder is securely attached to the backplate.

Breathing air cylinder assembly.

- Ensure the cylinder hydrostatic test date is current (Figure 6.56, p. 304).
- Inspect the cylinder gauge for cleanliness and damage.

Hydrostatic Test — Testing method that uses water under pressure to check the integrity of pressure vessels.



Figure 6.54 A facepiece regulator should be inspected for cleanliness, possible damage, and proper operation. *Courtesy of Kenneth Baum.*



Figure 6.55 Harness straps and backplate may show signs of damage through abrasion or searing. *Courtesy of Kenneth Baum.*



Figure 6.56 The hydrostatic test date indicates when the cylinder had its pressure valves confirmed. *Courtesy of Kenneth Baum.*

- Inspect the cylinder body for cracks, dents, weakened areas, and heat or chemicalinduced damage.
- Inspect composite cylinders for cuts, gouges, loose fibers, and missing resin material.
- Inspect the cylinder valve outlet sealing surface and threads for damage.
- Check the valve hand wheel for damage, proper alignment, serviceability, and secure attachment.
- Check the burst disc outlet area for debris.
- Check the cylinder to ensure that it is full.

Hoses.

- Inspect the high- and low-pressure hoses for abrasions, bubbling, cuts, cracks, and heat and chemical-induced damage.
- Inspect the hose fittings for cleanliness and damage.
- Visually check the high-pressure hose to cylinder "O" ring.
- Test the hose connections for tightness.

Low-pressure alarm.

- Inspect the low-pressure alarm and mounting hardware for cleanliness, proper attachment, and damage.
- Test the alarm for proper activation and operation.

Regulator.

- Inspect the regulator controls and pressure relief devices for cleanliness, proper operation, and damage.
- Inspect the housing and components for cleanliness and damage.
- Check the regulator for any unusual sounds during operation, such as whistling, chattering, clicking, or rattling.
- Check the mainline and bypass valve for proper function.

Pressure indicator gauges.

- Inspect the remote pressure indicator gauge for cleanliness and damage.
- Ensure that the pressure readings on the cylinder pressure gauge and remote gauge are within the manufacturer's recommended limits.

Integrated PASS.

- Inspect the PASS device for cleanliness, wear, and damage.
- Ensure all parts are securely attached to the PASS device.
- Test all operating modes for proper operation.
- Test the low battery warning signal for proper operation.

Care

You should clean and sanitize your SCBA facepiece immediately after each use to prevent debris from collecting in the exhalation valve and regulator fitting. Dirt or other foreign materials can cause the exhalation valve to malfunction and allow air from the tank to escape, quickly depleting the air supply. Debris can also prevent the regulator from fitting securely to the facepiece. Soot on the facepiece lens can reduce visibility.

Wash the facepiece thoroughly with warm water containing a mild commercial disinfectant and then rinse with clear, warm water (**Figure 6.57**). Take special care to ensure proper operation of the exhalation valve. Dry the facepiece with a lint-free cloth or air dry it. Do not use paper towels to dry the facepiece because they will scratch the facepiece lens. Although facepieces are impact resistant, they scratch easily. Regulators



Figure 6.57 Firefighters are responsible for cleaning and maintaining their assigned PPE and reporting repair needs as they occur.



and low-pressure hoses must not be submerged in water for cleaning. Sanitize the facepiece seal and interior of the facepiece to prevent you from inhaling or coming in contact with contaminants. This is especially important if you share the facepiece with other personnel. As with all maintenance, you should refer to the manufacturer's literature for instructions on proper care.

Facepiece lenses can also fog up internally due to the difference between the inside and outside temperatures. To prevent fogging, some SCBA facepieces are permanently treated with an antifogging chemical. Special antifogging chemicals recommended by the manufacturer can also be applied to the facepiece lens following cleaning.

Many departments issue firefighters with individual facepieces that are not shared with other firefighters. This practice eliminates the risk of spreading germs from one wearer to the next and ensures that the mask is the correct size, providing a complete seal. Even though firefighters have their own assigned facepieces, it is still important that they are cleaned after each use. Keeping facepieces clean and sanitized prevents hydrocarbons from contaminating your skin. When the facepiece is clean and dry it can be stored in a case, a bag, or coat pocket. Regardless of where the facepiece is stored, the straps should be left fully extended to facilitate donning. The procedures for cleaning an SCBA are given in **Skill Sheet 6-I-7**.

Annual Inspection and Maintenance

Annual inspection and maintenance must be performed by specially trained, factory-qualified technicians, in accordance with manufacturer's recommendations. These technicians may be trained members of the fire department or employees of a certified maintenance contractor. (Figure 6.58)

SCBA Air Cylinder Hydrostatic Testing

SCBA breathing air cylinders must be stamped or labeled with the date of manufacture and the date of the last hydrostatic test. According to both the U.S. Department of Transportation (49 CFR 180.205) and Transport Canada, the type of material used to construct the cylinder determines the frequency of hydrostatic testing. The testing frequency and life span of cylinders are as follows:

Figure 6.58 Equipment technicians may serve in dual roles, for example as EMTs and maintenance contractors. *Courtesy of Kenneth Baum.*

- Steel and aluminum cylinders are tested every five years and have an indefinite service life until they fail a hydrostatic test.
- Hoop-wrapped aluminum cylinders are tested every three years and have a 15-year service life.
- Fully wrapped fiberglass cylinders are tested every three years and have a 15-year service life.
- Fully wrapped Kevlar cylinders are tested every three years and have a 15-year service life.
- Fully wrapped carbon fiber cylinders are tested every five years and have a 15-year service life.

Refilling SCBA Cylinders

Three breathing air sources may be used to refill depleted SCBA air cylinders:

- Stationary fill systems
- Mobile fill systems
- Firefighter Breathing Air Replenishment Systems (FBARS): systems installed in high-rise buildings

Each source must provide Type 1 Grade D quality air to your cylinder, as specified by OSHA and Canadian government requirements. Regardless of the breathing air source, the following safety precautions apply when refilling an SCBA cylinder:

- Check the hydrostatic test date of the cylinder.
- Visually inspect the cylinder for damage.
- Don eye and hearing protection.
- Place the cylinder in a shielded fill station.
- Fill the cylinder slowly to prevent it from overheating.
- Ensure that the cylinder is completely full but not overpressurized.

Skill Sheet 6-I-8 provides a sample procedure for filling an SCBA cylinder from a cascade system. **Skill Sheet 6-I-9** provides a sample procedure for filling an SCBA cylinder from a compressor/purifier.

Filling unshielded cylinders while a firefighter is wearing the SCBA is prohibited. However, a rapid intervention crew or team (RIC/RIT) rescuing a trapped or incapacitated firefighter may be granted an exception to this rule. Even then, the following three criteria must be met before filling a worn SCBA:

- NIOSH-approved RIC Universal Air Connection (UAC) fill options are used.
- A risk assessment has been conducted to limit safety hazards and ensure that necessary equipment is fully operational.
- There is an imminent threat to the safety of the downed firefighter, and immediate action is required to prevent loss of life or serious injury.

Stationary Fill Stations

SCBA breathing air cylinders are filled either from a **cascade system** or directly from a compressor air purification system (**Figures 6.59 a and b, p. 308-309**). Cascade cylinders must meet American Society of Mechanical Engineers (ASME) design requirements. Both systems must be connected to a fill station that holds the SCBA

Cascade System — Three or more large, interconnected air cylinders, from which smaller SCBA cylinders are recharged; the larger cylinders typically have a capacity of 300 cubic feet (8,490 L).

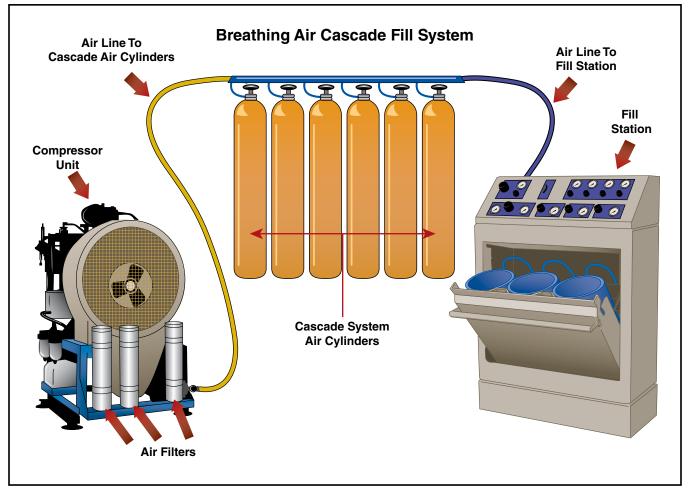


Figure 6.59 a A cascade fill system uses three or more large cylinders to refill smaller SCBA cylinders.

cylinders in rupture-proof sleeves during the filling process. If your department fills its own SCBA cylinders, you will be trained how to safely use the system. Some departments do not fill their own cylinders and contract the process out to a qualified breathing air supplier.

Filling procedures should be posted on the fill station and must follow the fill station manufacturer's recommendations to avoid excessive overheating in the cylinder. No matter how the cylinders are filled, the following safety precautions apply:

- Only trained personnel should operate the fill equipment.
- Cylinders must be inspected before filling.
- Hearing and eye protection must be worn during fill operations.
- Cylinders must be placed in the shielded fill station.
- Cylinders must be filled slowly to prevent overheating.
- Cylinders must be filled to their capacity.
- Cylinders must not be overfilled.

The breathing air quality must be regularly tested by a third-party testing facility, and the testing results must be documented. The department's health and safety officer is usually responsible for monitoring the testing and maintaining the documentation.

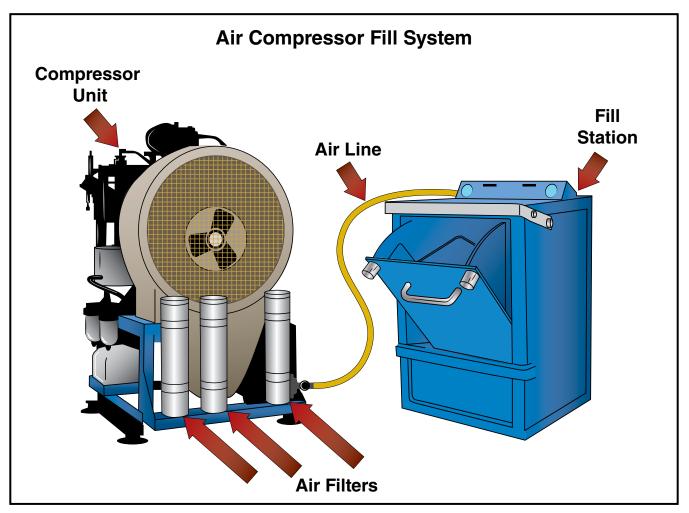


Figure 6.59 b A compressor fill system uses an air compressor to generate the pressure necessary to refill cylinders.

Mobile Fill Systems

Mobile breathing air fill systems are designed to refill air cylinders at emergency incidents. They typically consist of a fill station equipped with a breathing air compressor or cascade fill station and are mounted on a trailer or the apparatus chassis (**Figure 6.60**, **p. 310**). Cascade cylinders must meet U.S. Department of Transportation (DOT) or Transport Canada specifications.

The operation of the system will be similar to the stationary system previously mentioned. The system may also be designed to support a SAR system or a firefighter breathing air replenishment system (FBARS) installed in a high-rise structure, as described in the next section.

Firefighter Breathing Air Replenishment Systems (FBARS)

In 1988, the Los Angeles City Fire Department responded to a major high-rise fire. Although they eventually brought it under control, to do so they had to carry over 600 replacement SCBA cylinders to the top floors of a 62-story building. Post-incident analysis emphasized the fact that this was highly inefficient and a severe strain on personnel. To fight high-rise fires effectively, departments needed a better way to re-fill SCBA cylinders on upper floors.



Figure 6.60 A mobile fill system may be included in the equipment brought to an incident. *Courtesy of James Nilo.*

Figure 6.61 An installed breathing air system is required in new construction high-rise buildings. *Courtesy* of Brandon Wagoner.



In response to this problem, many municipalities now require that all newly constructed buildings taller than 75 feet (22.86 m) install Firefighter Breathing Air Replenishment Systems (FBARS) (**Figure 6.61**). FBARS provide an endless source of breathing air to any floor within the structure from a ground level connection. These systems typically consist of:

- A fire department air connection panel, containing connection fittings, control valves, and gauges, located on the exterior of the structure
- An Emergency Air Storage (EAS) system that provides breathing air if a mobile system is not available to supply the external connection

- Remote air fill panels, containing a certified rupture-proof containment fill station, connection and control valves, and gauges, located in protected stairwells on designated floors
- Interconnected piping certified to carry breathing air under pressure throughout the system
- Low air pressure monitoring switches and alarms, used to maintain a minimum air pressure and warn of pressure loss or system failure

Although not all high-rise buildings have these systems, their installation and use is increasing. In any jurisdiction with tall buildings, firefighters should know which structures have these systems and know how to use them.

Replacing SCBA Cylinders

SCBA backplates are designed for easy removal and replacement of breathing air cylinders. You may be required to replace the breathing air cylinder under the following circumstances:

- During the daily/weekly inspection, if the cylinder contains less than 90 percent of its capacity
- During training exercises
- During long-duration emergency operations
- After any emergency operations

Changing SCBA breathing air cylinders can be either a one- or two-person task. Skill Sheet 6-I-10 describes the one-person method for changing an air cylinder (Figure 6.62). When there are two people, the firefighter with an empty cylinder simply positions the cylinder so that it can be easily changed by the other firefighter. Skill Sheet 6-I-11 describes the two-person method for changing an air cylinder.

Empty cylinders should be kept separate from full cylinders that have been serviced and are ready for use. Damaged cylinders should be clearly marked and kept separate from both empty and full cylinders.



Figure 6.62 Breathing air cylinders must be replaced at regular intervals and under specific circumstances.



Figure 6.63 Activities that require interaction with a contaminated environment require the use of SCBA.

Using Respiratory Protection Equipment

Properly worn, maintained, and inspected respiratory protection equipment will prevent you from being exposed to airborne hazards. But to use it effectively, firefighters must also be aware of additional safety concerns, such as fatigue, regulating air supply, and proper exit procedures. The following sections describe the safety precautions to be used when wearing SCBA and explain how to properly exit an IDLH atmosphere.

Safety Precautions for SCBA Use

When using SCBA, you should follow these safety precautions:

- Only enter an IDLH atmosphere if you are certified to wear SCBA and have been properly fit tested for the facepiece.
- Closely monitor how you feel while wearing the SCBA. If you become fatigued, notify your supervisor and take a rest before returning to work.

- Remember that your air supply duration can vary, depending on:
 - Air cylinder size and beginning pressure
 - Your physical conditioning
 - The task being performed
 - Your level of training
 - The operational environment
 - Your level of stress
- After entering an IDLH atmosphere, keep your SCBA on and activated until you leave the contaminated area. Improved visibility does not ensure that the area is free of contamination (Figure 6.63). Before you remove your SCBA, the atmosphere must be tested with properly calibrated instruments and found to be safe.
- In any IDLH atmosphere, work in teams of two or more. Team members must remain in physical, voice, or visual contact with each other while in the hazardous area. Radio contact is not sufficient! If available, a thermal imager (TI) can help maintain contact.
- While in the IDLH atmosphere, check your air supply status frequently.
- Exit the IDLH atmosphere before the low air alarm activates to avoid using the reserve air supply.

Exit Indicators and Techniques

You should always be prepared to make a rapid exit or withdrawal. The most common exit procedures are those used at the majority of incidents, typically referred to as nonemergency exit procedures. Less common, but far more important, are emergency exit procedures. These are used in life-threatening situations such as SCBA failures and catastrophic changes during the incident.

Proper exit techniques must be practiced during training and followed during emergency incidents. Nonemergency exit procedures are covered in the following sections, while emergency exit procedures are covered in the firefighter survival section of Chapter 9, Building Search and Victim Removal.

Exit Indicators

There are many circumstances in which firefighters must exit contaminated or hazardous areas. Situations or events that signal the need for exit are called *exit indicators*.

Nonemergency exit indicators occur when:

- The situation is stabilized.
- There is a change in operational strategy.
- It is necessary to replace an air cylinder.
- The Incident Commander (IC) orders a nonemergency withdrawal.
- The assignment is completed.

Emergency exit indicators include:

- Activation of SCBA low-pressure low air alarm
- SCBA failure
- Withdrawal orders issued by the IC or Safety Officer
- Presence of APR/PAPR breakthrough symptoms

Permissible Exposure Limit (PEL) — Legal term for the maximum amount of a chemical substance or other hazard that an employee can be exposed to; typically expressed in parts per million (ppm) or milligrams per cubic meter (mg/m3). If exposed to this concentration for an entire 40-hour work week, 95% of healthy adults would not suffer health consequences.

- Activation of APR/PAPR end-of-service-life indicators
- Change in concentration of respiratory hazards
- Attaining or exceeding the **permissible exposure limit (PEL)** for a hazardous material while wearing an APR/PAPR
- Changes in environmental conditions, such as temperature, wind direction and speed, and water level and speed, either within or around the site of the incident
- Changes in oxygen level
- Changes in temperature
- Indications of new hazards

At any incident, the IC is responsible for constantly monitoring the environment. When monitoring reveals a potential hazard, such as chemical concentrations that approach the PEL, the IC issues orders to change the required level of respiratory protection or withdraw from the area completely.

One environmental change that firefighters may detect on their own is a change in oxygen level. Oxygen deficiency causes light-headedness, disorientation, loss of coordination, increased breathing rates, and rapid fatigue. If you experience any of these symptoms, report this by radio and evacuate the area immediately. APR canisters or cartridges that are exposed to increased levels of oxygen (above 23 percent) may also have unknown, adverse reactions that require you to evacuate.

Nonemergency Exit Techniques

Nonemergency exit techniques are based on the Incident Command System (ICS) and the accountability requirements of NFPA® 1500. You must be trained in nonemergency exit techniques including the buddy-system, controlled breathing, entry/ egress paths, and accountability systems.

Buddy system. In all hazardous atmospheres or situations, firefighters adhere to the buddy system by working in teams of at least two members (**Figure 6.64**). Each team member is responsible for the safety of the other member. At the first sign of any exit indicator (such as orders, low air alarm, or change in conditions), team members



Figure 6.64 All firefighters who will contact a hazardous atmosphere or situation must work in conjunction with a buddy. must leave as a group or in pairs. Individual members must never be left alone in the IDLH atmosphere. The only time one member may work alone is in a confined space where two members cannot fit. In this instance, the second team member remains outside the area monitoring the search line, ready to enter the space if the need for rescue arises.

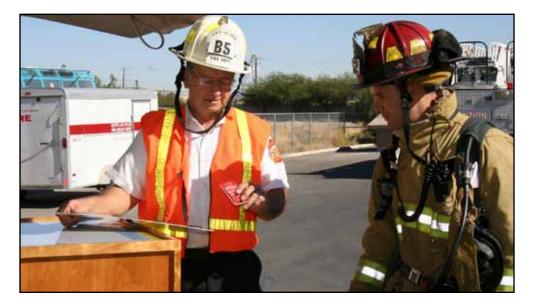
Controlled breathing. This technique allows for efficient air use in an IDLH atmosphere. Firefighters inhale naturally, through the nose, then forcefully exhale through the mouth, reducing air consumption. It is used primarily with SCBA, but can also be applied to APR/PAPRs, to extend the life of the filter and reduce the intake of toxins after a filter breakthrough.

Practice controlled breathing methods in training until they become second nature. Being conscious of breathing quickly slows breathing down, extending the life of your breathing air cylinder or APR/PAPR. Controlled breathing is an important exit technique because it reduces air consumption during the time required to exit.

Egress paths. When you exit an IDLH area, it is important to use the same path that you used to enter. This path will have familiar landmarks, and it may also be the most direct. This method is especially important in unfamiliar structures because it reduces the possibility that you will become lost or disoriented and allows you to calculate the time it will take to exit the area. Make a habit of this technique by practicing it during training.

However, you must be aware of other means of egress in case your entry route is blocked. One exit technique is to follow hoselines or search lines out of an area. Always apply your situational awareness as you arrive at the scene of an incident and prepare to enter the structure. Look for other possible exit points, note any potential obstructions, and observe the fire conditions visible at the time you enter the IDLH area.

Accountability systems. Accountability systems to keep track of personnel in an IDLH environment are required by NFPA® 1500. Individual departments have different accountability SOPS, but typically firefighters must check in with the accountability officer before entering the IDLH area. All personnel, their locations, and their functions are then noted on a tracking board or some other tracking system. When firefighters leave the IDLH area, they check out with the accountability officer so that they are not counted as missing (Figure 6.65). Many firefighter fatalities can be attributed to improper use of the accountability system.



Search Line — Nonload-bearing rope that is anchored to a safe, exterior location and attached to a firefighter during search operations to act as a safety line.

Figure 6.65 Accountability systems enable officers to confirm that each firefighter has left the IDLH atmosphere.



Chapter Summary

Firefighters are frequently exposed to dangerous environments in which personal protective equipment is necessary to maintain health and safety. Your PPE will protect you from hazards and minimize the risk of injury or fatality, but only if it is properly worn, cleaned, and maintained.

Respiratory protection equipment protects you from toxic gases and vapors, particulates, and disease. But like your PPE, it can only do so if it is properly used, inspected, cleaned, and

maintained. In addition to performing all of these tasks, you must know how to choose the type of respiratory equipment that is appropriate for the hazardous atmosphere you face. You must also know how to manage your air supply so that you can exit an IDLH area before your low-pressure air alarm activates.

End-of-Chapter Review Questions

Firefighter I

- 1. What is the purpose of personal protective equipment?
- 2. Why are there differences in the characteristics of structural fire fighting protective clothing and wildland personal protective clothing?
- 3. What are some basic guidelines for the care of personal protective clothing?
- 4. What safety considerations do firefighters need to keep in mind when using personal protective equipment?
- 5. What common respiratory hazards do firefighters face?
- 6. How do atmosphere-supplying respirators differ from air-purifying respirators?
- 7. What are some of the limitations of respiratory protection equipment?
- 8. What should respiratory equipment be protected from during storage?
- 9. What general considerations need to be taken when donning and doffing protective breathing apparatus?
- 10. What are the general inspection and care considerations for protective breathing apparatus?
- 11. What kinds of safety precautions should be taken when refilling SCBA cylinders?
- 12. What methods can you use to replace an SCBA cylinder?
- 13. What are the safety precautions taken when using an SCBA?
- 14. What are common emergency and nonemergency exit indicators a firefighter may encounter during an incident?
- 15. What are some nonemergency exit techniques firefighters can use?



NOTE: Ensure ensemble is worn according to manufacturer's guidelines or local standard operating procedures.



Step 1: Don pants and boots, which includes suspenders in place.

Step 2: Don hood.



Step 3: Don coat with closure secure and collar up.



Step 4: Don helmet with eye protection on and chin strap in place and fastened.



Step 5: Don structural firefighter gloves.

SKILL SHEETS

NOTE: The following are general procedures for donning an SCBA. The specific SCBA manufacturer's recommendations for donning and use of the SCBA should always be followed.



Step 1: Position the SCBA with the valve end of the cylinder away from the body, the cylinder down, and back frame up. All harness straps are fully extended and untangled.

Step 2: Open cylinder valve fully. Listen for the activation of the integrated PASS Alarm if equipped. Listen for the activation of the Low Air Alarm.

Step 3: Check cylinder and regulator pressure gauges. Pressure readings within 100 psi OR needles on both pressure gauges indicate same pressure.



Step 4: Grab the back frame so that the shoulder straps will be outside of arms. Using proper lifting techniques, raise the SCBA overhead while guiding elbows into the loops formed by the shoulder straps.

Step 5: Release the harness assembly and allow the SCBA to slide down the back.

Step 6: Fasten chest strap, buckle waist strap, and adjust shoulder straps.

Step 7: Don facepiece over the head and securely tighten the straps, pulling the straps straight backwards, not out to the side.





Step 8: After straps are tightened, test the facepiece for a proper seal and operation of the exhalation valve.

NOTE: Not all facepieces are designed for a seal check without the regulator being attached and activated.

Step 9: Don hood, ensure it covers all exposed skin.

Step 10: Connect air supply to facepiece.



Step 11: Activate external PASS device, if not equipped with integrated device.

Step 12: Don helmet, with chin strap secure and adjusted, and gloves.

SKILL SHEETS

NOTE: The following are general procedures for donning an SCBA. The specific SCBA manufacturer's recommendations for donning and use of the SCBA should always be followed.



Step 1: Position SCBA with the valve end of the cylinder toward the body, the cylinder down, and back frame up. All harness straps are fully extended and untangled.

Step 2: Open cylinder valve fully. Listen for the activation of the integrated PASS Alarm if equipped. Listen for the activation of the Low Air Alarm.

Step 3: Check cylinder and regulator pressure gauges. Pressure readings within 100 psi OR needles on both pressure gauges indicate same pressure.



Step 4: Grasp the top of the left shoulder strap on the SCBA with the left hand and raise the SCBA overhead.

Step 5: Guide left elbow through the loop formed by the left shoulder strap and swing SCBA around left shoulder.

Step 6: Guide right arm through the loop formed by the right shoulder strap allowing the SCBA to come to rest in proper position.





Step 7: Fasten chest strap, buckle waist strap, and adjust shoulder straps.

Step 8: Don facepiece over the head and securely tighten the straps, pulling the straps straight backwards, not out to the side.



Step 9: After straps are tightened, test the facepiece for a proper seal and operation of the exhalation valve.

NOTE: Not all facepieces are designed for a seal check without the regulator being attached and activated.

Step 10: Don hood, ensure it covers all exposed skin.

Step 11: Connect air supply to facepiece.

Step 12: Activate external PASS device, if not equipped with integrated device.

Step 13: Don helmet, with chin strap secure and adjusted, and gloves.

SKILL SHEETS

NOTE: The following are general procedures for donning an SCBA. The specific SCBA manufacturer's recommendations for donning and use of the SCBA should always be followed.



Step 1: Position body in seat with back firmly against the SCBA and release the SCBA hold-down device.

Step 2: Insert arms through shoulder straps.



Step 3: Fasten chest strap, buckle waist strap, and adjust shoulder straps.

Step 4: Fasten seat belt before apparatus gets underway.

Step 5: Safely dismount apparatus, using appropriate situational awareness.

Step 6: Open cylinder valve fully.

Step 7: Check cylinder and regulator pressure gauges. Pressure readings within 100 psi OR needles on both pressure gauges indicate same pressure.

Step 8: Don facepiece over the head and securely tighten the straps, pulling the straps straight backwards, not out to the side.





Step 9: After straps are tightened, test the facepiece for a proper seal and operation of the exhalation valve.

NOTE: Not all facepieces are designed for a seal check without the regulator being attached and activated.

Step 10: Don hood, ensure it covers all exposed skin.

Step 11: Connect air supply to facepiece.

Step 12: Activate external PASS device, if not equipped with integrated device.

Step 13: Don helmet, with chin strap secure and adjusted, and gloves.



Doff SCBA



Step 1: Remove SCBA.

Step 2: Close cylinder valve completely.

Step 3: Bleed air from high and low pressure hoses, listen for low air alarm activation.

Step 4: Check air cylinder pressure and replace or refill cylinder if less than 90% of rated capacity.



Step 5: Return all straps, valves and components back to ready state.

Step 6: Inspect SCBA and facepiece for damage and need for cleaning.

Step 7: Clean equipment as needed and remove damaged equipment from service and report to company officer, if applicable.

Step 8: Place SCBA back in storage area so that it is ready for immediate use.



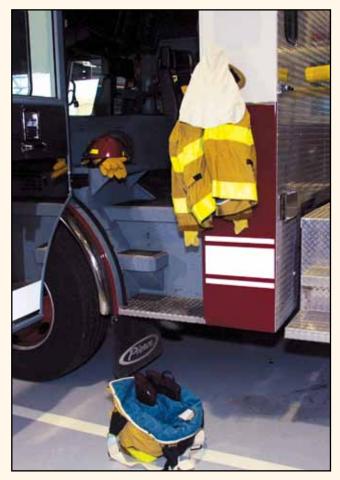
Doff PPE

Step 1: Remove protective clothing.



Step 2: Inspect PPE for damage and need for cleaning.

Step 3: Clean equipment as needed and remove damaged equipment from service and report to company officer, if applicable.



Step 4: Place clothing in a ready state.

SKILL SHEETS



Step 1: Identify all components of SCBA are present: harness assembly, cylinder, facepiece, and PASS device.

Step 2: Inspect all components of SCBA for cleanliness and damage.

Step 3: Immediately clean dirty components if found. If damage is found, remove from service and report to company officer.

Step 4: Check that cylinder is full (90%-100% of capacity).

Step 5: Open the cylinder valve slowly; verify operation of the low-air alarm and the absence of audible air leaks.

NOTE: On some SCBA, the audible alarm does not sound when the cylinder valve is opened.

Step 6: If air leaks are detected, determine if connections need to be tightened or if valves, donning switch, etc. need to be adjusted. Otherwise SCBA with audible leaks due to malfunctions shall be removed from service, tagged, and reported to the company officer.



Step 7: Check that gauges and/or indicators (i.e. heads-up display) are providing similar pressure readings. Manufacturers' guidelines determine the acceptable range.

Step 8: Check the function of all modes of PASS device.



Step 9: Don facepiece over the head and securely tighten the straps, pulling the straps straight backwards, not out to the side.

Step 10: After straps are tightened, test the facepiece for a proper seal and operation of the exhalation valve.

NOTE: Not all facepieces are designed for a seal check without the regulator being attached and activated.

Step 11: Don regulator and check function by taking several normal breaths.

Step 12: Check bypass and/or purge valve, if applicable.

Step 13: Remove facepiece and prepare all components for immediate reuse.

Step 14: Place SCBA components so that they can be accessed quickly for donning in the event of a reported emergency.





Step 1: Prepare cleaning solution, buckets, etc. according to manufacturer's guidelines and departmental policies.



Step 4: Place all components in a manner and location so that they will dry.



Step 2: Clean all components of SCBA unit according to manufacturer's guidelines and departmental policies.

Step 3: After equipment is clean, inspect for damage. If any damage is noted, report in accordance with local SOPs.



Step 5: Assemble components so they are in a state of readiness.



NOTE: This skill sheet is only an example. The procedures outlined here may not be applicable to your cascade system. Always check the manufacturer's instructions before attempting to fill any cylinders.



Step 1: Check the hydrostatic test date and recommended fill pressure of the cylinder.



Step 2: Inspect the SCBA cylinder for damage such as deep nicks, cuts, gouges, or discoloration from heat. If the cylinder is damaged or is out of hydrostatic test date, remove it from service and tag it for further inspection and hydrostatic testing.

CAUTION: Never attempt to fill a cylinder that is damaged or that is out of hydrostatic test date.

Step 3: Place the SCBA cylinder in a fragment-proof fill station.



Step 4: Connect the fill hose to the cylinder and close bleed valve on fill hose.

Step 5: Open the SCBA cylinder valve.

Step 6: Open the valve at the fill hose, the valve at the cascade system manifold, or the valves at both locations if the system is so equipped. Check that the regulator setting is appropriate for the cylinder pressure.



NOTE: Some cascade systems may have a valve at the fill hose, at the manifold, or at both places.

Step 7: Open the valve of the cascade cylinder that has the least pressure but that has more pressure than the SCBA cylinder.





Step 8: Close the cascade cylinder valve when the pressures of the SCBA and the cascade cylinder equalize.

- a. If the SCBA cylinder is not yet completely full, open the valve on the cascade cylinder with the next highest pressure.
- **b.** Repeat Step 8 until the SCBA cylinder is completely full.



Step 9: Close the valve or valves at the cascade system manifold and/or fill line if the system is so equipped.

Step 10: Close the SCBA cylinder valve.



Step 11: Open the hose bleed valve to bleed off excess pressure between the cylinder valve and the valve on the fill hose.

CAUTION: Failure to open the hose bleed valve could result in O-ring damage.



Step 12: Disconnect the fill hose from the SCBA cylinder.

Step 13: Remove the SCBA cylinder from the fill station.

Step 14: Return the cylinder to proper storage.



NOTE: This skill sheet is only an example. The procedures outlined here may not be applicable to your compressor/purifier system. Always check the compressor/purifier manufacturer's instructions before attempting to fill any cylinders.



Step 1: Check the hydrostatic test date of the cylinder.



Step 4: Connect the fill hose to the cylinder and close bleed valve on fill hose.

Step 5: Open the SCBA cylinder valve.



Step 2: Inspect the SCBA cylinder for damage such as deep nicks, cuts, gouges, or discoloration from heat. If the cylinder is damaged or out of hydrostatic test date, remove it from service and tag it for further inspection and hydrostatic testing.

CAUTION: Never attempt to fill a cylinder that is damaged or that is out of hydrostatic test date.

Step 3: Place the SCBA cylinder in a shielded fill station.

Step 6: Turn on the compressor/purifier and open the outlet valve.



Step 7: Set the cylinder pressure adjustment on the compressor (if applicable) or manifold to the desired full-cylinder pressure. If there is no cylinder pressure adjustment, watch the pressure gauge on the cylinder during filling to determine when it is full.





Step 8: Open the manifold valve (if applicable), and again check the fill pressure.

Step 9: Open the fill station valve and begin filling the SCBA cylinder.



Step 13: Disconnect the fill hose from the SCBA cylinder.



Step 10: Close the fill station valve when the cylinder is full.

Step 11: Close the SCBA cylinder valve.

Step 12: Open the hose bleed valve to bleed off excess pressure between the cylinder valve and valve on the fill station.

CAUTION: Failure to open the hose bleed valve could result in O-ring damage.



Step 14: Remove the SCBA cylinder from the fill station and return the cylinder to proper storage.

SKILL SHEETS



- **Step 1:** Place the SCBA unit on a firm, clean surface.
- **Step 2:** Fully close the cylinder valve.
- **Step 3:** Release air pressure from high- and low-pressure hoses.
- **Step 4:** Disconnect the high-pressure coupling from the cylinder.
- **Step 5:** Remove the empty cylinder from harness assembly.

Step 6: Verify that replacement cylinder is 90-100% of rated capacity.

Step 7: Check cylinder valve opening, the high-pressure hose fitting for debris, and the O-ring.

Step 8: Place the new cylinder into the backpack.



Step 9: Connect the high-pressure hose to the cylinder and hand-tighten.

Step 10: Slowly and fully open the cylinder valve and listen for an audible alarm and leaks as the system pressurizes.

NOTE: On some SCBA, the audible alarm does not sound when the cylinder valve is opened. You must know the operation of your own particular unit.





Step 11: If air leaks are detected, determine if connections need to be tightened or if valves, donning switch, etc. need to be adjusted. Otherwise SCBA with audible leaks due to malfunctions shall be removed from service, tagged, and reported to the officer.

Step 12: Don regulator and take normal breaths.



Step 13: Check pressure reading on remote gauge and/or indicators and report reading.





Step 1: Disconnect the regulator from the facepiece or disconnect the low-pressure hose from the regulator.

Step 2: Position the cylinder for easy access by kneeling down or bending over.

Step 3: Fully close the cylinder valve.

Step 4: Release the air pressure from the high- and low-pressure hoses.

Step 5: Disconnect the high-pressure coupling from the cylinder.

Step 6: Remove the empty cylinder from harness assembly.

Step 7: Inspect replacement cylinder and ensure that cylinder is 90-100% of rated capacity.

Step 8: Place new cylinder into the harness assembly.

Step 9: Check the cylinder valve opening and the highpressure hose fitting for debris, clearing any debris by quickly opening and closing cylinder valve, and the O-ring.

Step 10: Connect the high-pressure hose to the cylinder and hand-tighten.



Step 11: Slowly open the cylinder valve fully and listen for an audible alarm and leaks as the system pressurizes.

NOTE: On some SCBA, the audible alarm does not sound when the cylinder valve is opened. You must know the operation of your own particular unit.

Step 12: If air leaks are detected, determine if connections need to be tightened or if valves, donning switch, etc. need to be adjusted. Otherwise SCBA with audible leaks due to malfunctions shall be removed from service, tagged, and reported to the officer.

Step 13: Don regulator and take normal breaths.

Step 14: Check pressure reading on remote gauge and/or indicators and report reading.



NFPA® Safety Alert Issued for SCBA Facepiece Lenses

On July 2, 2012, the National Fire Protection Association® issued the following safety alert:

Safety Alert

Exposure to high temperature environments, which firefighters can encounter during fires they are attempting to extinguish, can result in the thermal degradation or melting of a Self-Contained Breathing Apparatus (SCBA) facepiece lens, resulting in elimination of the protection meant for the user's respiratory system and exposing the user to products of combustion and super heated air.

This alert was based on data gathered by the National Institute for Occupational Safety and Health (NIOSH) while investigating firefighter line of duty deaths between 2002 and 2011. The investigations into three fatalities indicated that firefighters encountered thermal conditions that exceeded the level of protection the facepiece lenses were designed to withstand. At the same time it was determined that the facepiece lens offered the lowest level of thermal protection of any part of the personal protective ensemble. The degradation of the lens resulted in the inhalation of products of combustion and thermal injuries to the firefighter's respiratory system.

The NFPA® will be incorporating new test methods and performance requirements into the 2013 edition of NFPA® 1981, *Standard on Open-Circuit Self-Contained Breathing Apparatus (SCBA) for Emergency Services*. In the meantime, the NFPA® made the following recommendations:

- SCBA facepieces should be inspected before and after each use in accordance with NFPA® 1852, Selection Care and Maintenance of Open-Circuit Self-Contained Breathing Apparatus.
- SCBA facepieces that exhibit evidence of exposure to intense heat, such as cracking, crazing, bubbling, discoloration, deformation, or gaps between the lens and frame must be removed from service and repaired or replaced.
- Fire department training programs must contain information on the limitations of respiratory protection, the effects on the facepiece of prolonged or repeated exposures to intense heat, and how to respond to problems that may occur when the facepiece is exposed to intense heat.
- When firefighters and fire officers are evaluating structure fires they must consider the potential for facepiece failure during an interior fire attack. Situational awareness and an understanding of fire behavior are essential to preventing facepiece failure.
- When interior conditions deteriorate, firefighters must be able to recognize the change in conditions and withdraw or seek a safe refuge.