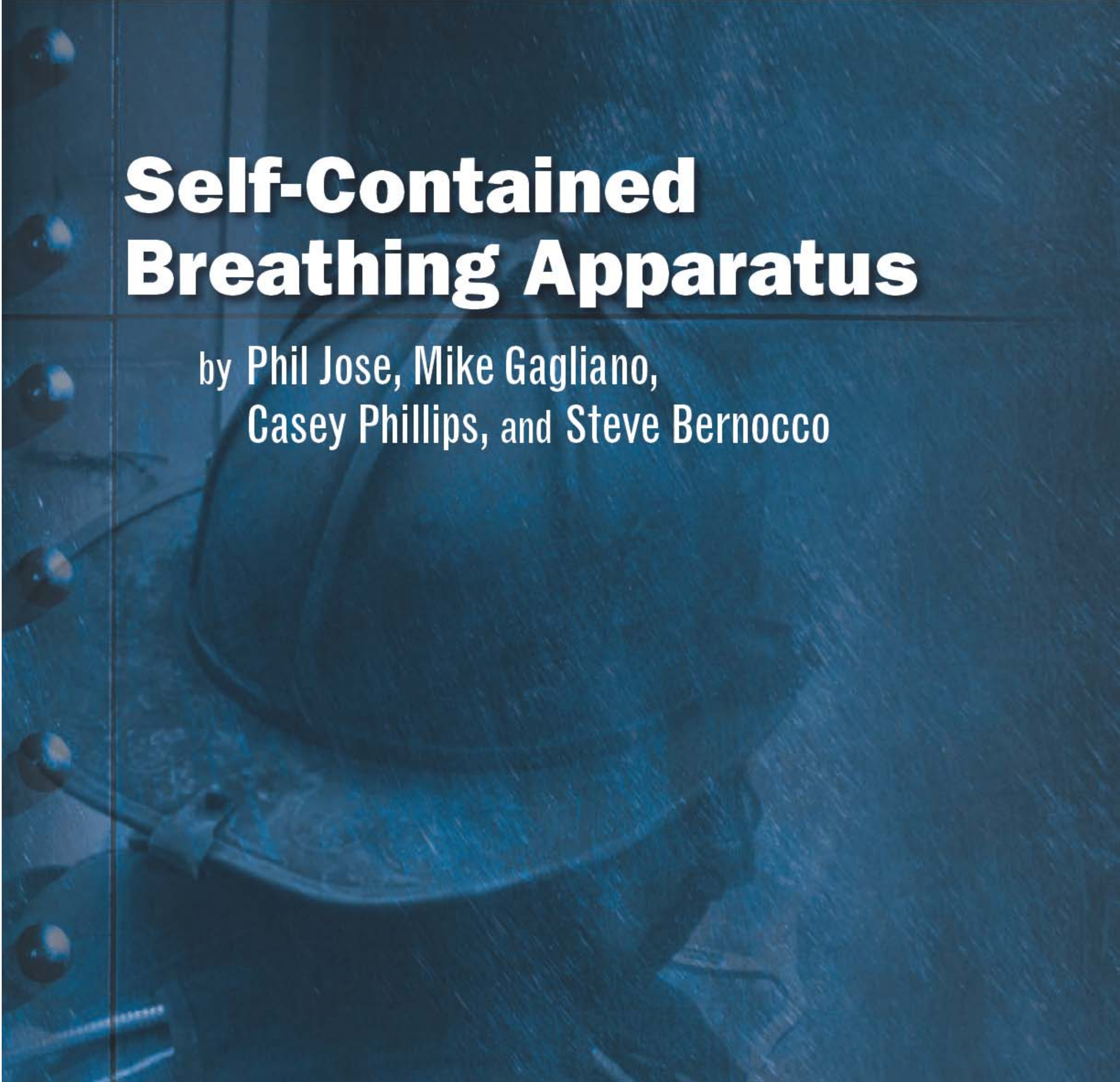

Self-Contained Breathing Apparatus

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This chapter provides required knowledge items for the following NFPA Standard 1001 Job Performance Requirements:

FFI 5.3.1

FFI 5.3.10

FFI 5.3.11

FFI 5.5.1

This chapter contains Skill Drills. When you see this icon, refer to your Skill Drill book for step-by-step instructions.

OBJECTIVES

Upon completion of this chapter, you should be able to do the following:

- List types of respiratory devices for fire and non-fire applications
- Describe how self-contained breathing apparatus (SCBA) protects the user at an emergency incident
- List the physical requirements needed by a user of SCBA
- List and describe the major components of an SCBA
- Describe and demonstrate the approved methods of donning and doffing SCBA
- Describe and demonstrate installing an SCBA regulator
- Describe and demonstrate changing SCBA cylinders and filling them
- List three activities accomplished by firefighters while wearing SCBA
- Describe how air consumption rates impact the use of SCBA at an emergency incident
- Describe the procedures for exiting a hazardous area while on emergency reserve air supply
- Describe the proper emergency measures to take when there is a failure of the SCBA
- Describe and demonstrate the proper inspection and maintenance procedures for SCBA
- Describe and demonstrate periodic inspections of SCBA unit
- Describe and demonstrate cleaning an SCBA

INTRODUCTION

This chapter introduces you to the open-circuit **self-contained breathing apparatus (SCBA)**, and includes the necessary information to meet the requirements for National Fire Protection Association (NFPA) Firefighter I and Firefighter II from NFPA 1001, *Standard for Fire Fighter Professional Qualifications*; components of NFPA 1500, *Standard on Fire Department Occupational Safety and Health*; and components of NFPA 1981, *Standard on Open-Circuit Self-Contained Breathing*

Apparatus (SCBA) for Emergency Services. These standards require firefighters to be trained in accordance with NFPA 1404, *Standard for Fire Service Respiratory Protection Training.*

OVERVIEW

Fire departments provide firefighters with many types of respiratory protection so firefighters can operate safely in all kinds of hazardous environments. Respiratory protection can include various levels of protection, from the paper dust filter-style mask to the SCBA. This chapter focuses on the SCBA as the tool of choice for respiratory protection while performing duties at a structural fire. It also provides a brief introduction to three types of respiratory protection for special applications ranging from fire investigation to confined space entry.

RESPIRATORY PROTECTION FOR NONFIRE APPLICATIONS

Fire departments often have air purifying respirators (APRs) for use by fire service personnel, like those worn by fire investigators (fig. 10–1). APRs have particulate or chemical filters that must be matched to the specific situation in which they are to be used. APRs have particulate filters, chemical filters, or combination filters to clean the air breathed by the user. Although APRs do not supply breathing air from a known source, they filter the ambient air surrounding the user. For this reason they cannot be used in oxygen-deficient atmospheres (less than 19% oxygen).

Fire departments may also use the powered air purifying respirator (PAPR), which has the same limitations as the APR (fig. 10–2). The primary advantage of the PAPR over the APR is that the PAPR unit provides a blower that supplies air to the user. This supplied air reduces the effort needed by the user to breathe, thereby reducing overall fatigue and increasing the work time of the user. Neither the APR nor the PAPR is approved for use by structural firefighters while operating at the scene of a working fire.

The supplied air respirator (SAR) is another type of respiratory protection that is available for fire department operations (fig. 10–3). The SAR provides breathable air to the user from a remote source through an air supply line. Fire departments use the SAR primarily for confined space operations. The SAR can be used safely and effectively by trained personnel in known and properly controlled operational environments. The SAR, when used in fire department operations, includes some type of escape cylinder that is carried by the user in case of failure of the air supply line or the need for the user to immediately exit the space without time to manage the air supply line during exit. The SAR is not approved for structural firefighting and requires additional training.

Fig. 10–1. Sample of an APR often used during fire investigations. (Courtesy of Mine Safety Appliances)

Fig. 10–2. A PAPR with the battery pack attached. (Courtesy of Mine Safety Appliances)

Fig. 10–3. This sample of a SAR shows the air supply line attached. You can also see the small escape cylinder on the waist belt. This cylinder is used for emergency egress only. (Courtesy of Mine Safety Appliances)

SELF-CONTAINED BREATHING APPARATUS

SCBA is the firefighter's tool for breathing air in structural fire environments (fig. 10–4). SCBA is a time-tested and reliable method for firefighters to have safe, breathable air while operating in the most extreme of environments. Modern SCBA are designed and stringently tested to meet the requirements of NFPA 1981 *Standard on Open-Circuit Self-Contained Breathing Apparatus (SCBA) for Emergency Services, 2006 Edition.*

Fig. 10–4. In some cases, it is necessary to use SCBA outdoors when smoke conditions dictate.

USE OF SELF-CONTAINED BREATHING APPARATUS AT EMERGENCIES

FFI 5.3.1 SCBA provides an excellent level of respiratory protection for firefighters engaged in operations at structural fires. Firefighters are provided a known quantity of breathable air for operations in immediately dangerous to life and health (IDLH) or potential IDLH environments. The IDLH environment at structural fires includes gases produced by the combustion of the building and its contents (fig. 10–5).

Fig. 10–5. This firefighter is preparing to make entry into a known IDLH environment. His respiratory protection protects him and allows him to complete his assigned duties safely and effectively. (Courtesy of Lt. John Lewis, Passaic, New Jersey, Fire Department)

FFI 5.3.10 **FFI 5.3.11** The gases produced during a fire are toxic. The gases are carcinogenic. The combination of toxic and carcinogenic is IDLH for the firefighters. A common example is carbon monoxide (CO), which is present at all structural fires. CO has a much stronger affinity to red blood cells than oxygen (O) and works to displace the blood's ability to carry oxygen. The effects of CO can be seen in (table 10–1). Breathing the gases created during a fire can cause serious injury or death, even from a single exposure. The combination of toxic and carcinogenic is eventually dangerous to the firefighter's life and health. Low-level exposures to fire gases over the long term can cause serious health problems, including cancer (fig. 10–6).

Fig. 10–6. Before SCBA were readily available, firefighters were exposed to toxic gases while operating on the roof of the fire building. Firefighters from this era were at elevated risk for cancer because of their exposure. There is no excuse for this type of behavior on the modern fireground. (Courtesy of Seattle Firefighters Local 27)

Firefighters often underestimate the long-term damage produced by small exposures to toxic gases. There is often a cultural bias in favor of using the mask as little as possible. The reality of the modern smoke environment requires the firefighter to use the SCBA whenever any smoke is present. If you want a long and healthy career followed by a long and healthy retirement, do not breathe smoke.

The following is a brief description of a few fire gases and their effect.[1]

The deadly duo: polyvinyl chloride and hydrogen cyanide

Two of the least recognized components of the modern smoke environment are **polyvinyl chloride (PVC)** and **hydrogen cyanide (HCN)**. The former is a product present in large quantities at most fires today, whereas the latter is a deadly by-product that is the silent killer of the fireground.

PVC, a type of plastic similar to that used in plumbing piping, is likely to be found in more abundance than any other product in today's homes. It is devastating to the firefighter no matter where they are in the smoke as its deadly fumes are emanating from materials at every level of structure. Its "emissions during fires of benzene, chlorinated dioxins, and dibenzofurans, known carcinogens, appears to explain the high frequencies of leukemia, laryngeal and colon cancer, and of rare soft tissue cancers found in many firefighters at relatively young ages."[2] PVC fires also include the presence of the highly acidic gas hydrogen chloride and other gases that impact respiratory and circulatory health.

Hydrogen cyanide is a colorless, odorless gas that emanates from both natural and synthetic sources (fig. 10–7). Unlike carbon monoxide, a common cause of death in firefighters, hydrogen cyanide is relatively unknown; but it is steadily assuming a more prominent place in the hierarchy of the causes of death at fires. It was the gas of choice for Hitler's death camps (Zyklon B) and the method the terrorists of the Aum Shynrikio religious cult attempted to use in their attack on the Shinjuku Station in Tokyo (May 5, 1995).

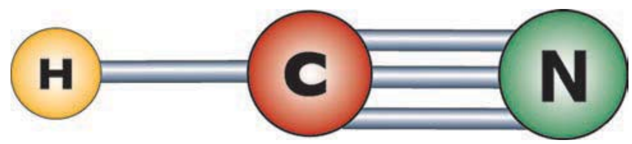

Fig. 10–7. Hydrogen cyanide molecule

A more comprehensive list of chemicals can be seen in table 10–1. Firefighters should understand that these gases are present at every fire. These gases can cause short- and long-term health problems. Furthermore, they can cause the immediate death of a firefighter from a single breath. Firefighters should not breathe smoke. The correct tool to prevent the exposure of firefighters is the SCBA. There is no better way to protect the health of the firefighter than a well-maintained, properly worn, SCBA.

Table 10–1. Toxic effects of carbon monoxide

Carbon monoxide (CO) (ppm)	Carbon monoxide in air (%)	Symptoms
100	0.01	No symptoms-no damage
200	0.02	Mild headache; few other symptoms
400	0.04	Headache after 1–2 hours
800	0.08	Headaches after 45 minutes; nausea, collapse, and unconsciousness after 2 hours
1,000	0.1	Dangerous; unconscious after 1 hour
1,600	0.16	Headache, dizziness, nausea after 20 minutes
3,200	0.32	Headache, dizziness, nausea after 5–10 minutes; unconsciousness after 30 minutes
6,400	0.64	Headache, dizziness, nausea after 1–2 minutes; unconsciousness after 10–15 minutes
12,800	1.26	Immediate unconsciousness, danger of death in 1–3 minutes

Table 10–2. Fire gases and their effect on the human body

Table of primary fire gas toxicities

Gas	Assumed LC50 (ppmv) 5 min	Assumed LC50 (ppmv) 30 min
Acetaldehyde	—	20,000
Acetic acid	—	11,000
Ammonia	20,000	9,000
Hydrogen chloride	16,000	3,700
Hydrogen bromide	—	3,000
Nitric oxide	10,000	2,500
Carbonyl sulfide	—	2,000
Hydrogen sulfide	—	2,000
Hydrogen fluoride	10,000	2,000
Acrylonitrile	—	2,000
Carbonyl fluoride		750
Nitrogen dioxide	5000	500
Acrolein	750	300
Formaldehyde	—	250
Hydrogen cyanide	280	135
Toluene diisocyanate	—	100
Phosgene	50	90
Perfluoroisobutylene	28	6

THE SCBA IN THE POSTFIRE ENVIRONMENT

In the postfire environment, the contents of the structure begin to cool. These contents continue to release toxic gases at lower concentrations. Many gases are the same as those produced during the active fire stage of the incident. Firefighters must be aware that, although a postfire environment may appear clear, toxic gases such as hydrogen cyanide and carbon monoxide and cancer-causing agents such as benzene are still released into the atmosphere (table 10–2). For this reason, firefighters should continue to wear SCBA after the fire is out and during all overhaul activities. In addition, the use of total flooding fire extinguishing system agents such as carbon dioxide (covered in chapter 30: Fire Protection Systems), an asphyxiating gas that is heavier than air, may remain after the fire has been extinguished.

Many fire departments use some type of gas detector to identify the level of CO present in the postfire environment. This is a weak attempt to identify that the air is safe enough to breathe to permit firefighters to operate without SCBA. However, this practice is strongly discouraged. There is ample evidence that low CO readings do not indicate the absence of other toxic and cancer-causing gases in the atmosphere. Keep in mind that CO readings do not provide information about particulate matter, such as asbestos, suspended in the air that will be inhaled by firefighters not wearing SCBA (fig. 10–8).

Fig. 10–8. Firefighters conducting overhaul operations without SCBA are exposed to toxic and cancer-causing gases. Firefighters should always wear respiratory protection in the postfire environment. (Courtesy of Seattle Firefighters Local 27)

The postfire environment, while not necessarily an IDLH environment, is a time when firefighters without SCBA are exposed to chemicals that are known to cause cancer. There is no reason to knowingly expose firefighters to these dangerous gases and chemicals when the SCBA can provide excellent protection. The SCBA provides protection for the user's respiratory tract (fig. 10–9) from toxic and superheated gases. The SCBA also provides a significant level of protection to the user's face and eyes. However, the SCBA does not protect the user from exposure to chemicals absorbed through the skin.

Many SCBA are approved by the National Institute for Occupational Safety and Health (NIOSH) to provide respiratory protection in **chemical, biological, radiological, and nuclear (CBRN)** environments. NIOSH performs extensive testing of SCBA assemblies for compliance with a variety of federal standards. As those standards apply to firefighter and CBRN qualification, here is what NIOSH reads about their testing:

> **To Protect Emergency Responders Against CBRN Agents in Terrorist Attacks**
>
> *The U.S. Centers for Disease Control and Prevention's (CDC) National Institute for Occupational Safety and Health (NIOSH) has a program to approve self-contained breathing apparatus (SCBA) for use by fire fighters and other first responders to terrorist attacks. NIOSH approval under the program signifies that an SCBA is expected to provide needed protection to first responders in situations where an act of terror has released harmful chemicals, pathogens, or radioactive materials into the air. Approvals are based on positive results from rigorous tests on sample units submitted to NIOSH by manufacturers, and from stringent evaluation of manufacturers' quality-control practices, technical specifications, and other documentation.*

To ensure protection in CBRN environments, the firefighter should look for a CBRN-NIOSH Agent Approval label on the SCBA assembly. If there is no CBRN Agent Approval label, or it has been removed or destroyed, the SCBA is not approved for use by firefighters in the environment.

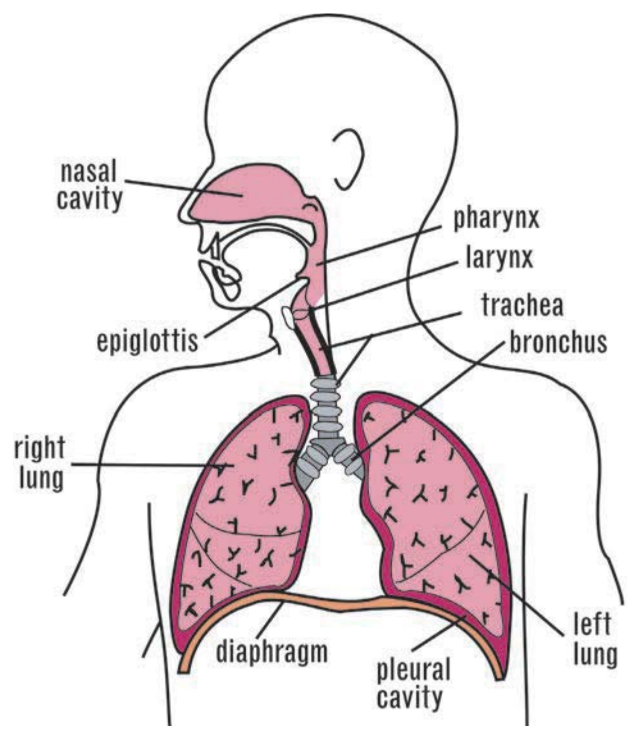

Fig. 10–9. Respiratory tract

PHYSICAL REQUIREMENTS OF THE USER

Firefighting is an extreme physical activity. Firefighters must use SCBA during all phases of firefighting operations in areas that are or could become IDLH. Fire departments should ensure that any person trained to use SCBA for emergency operations receives appropriate medical screening. Firefighting is an ultra-hazardous occupation, and the leading cause of death for firefighters is cardiac arrest. This fact alone should provide ample incentive for fire departments to ensure that all personnel engaged in emergency operations in IDLH environments receive medical screening that complies with all applicable standards. Medical screening should be performed before SCBA training and should continue to be performed annually as long as the firefighter is responding to emergency scenes.

In addition to appropriate screening, the properly trained firefighter must understand that there are multiple layers of regulations regarding the use of the SCBA in IDLH environments. These include local, state, and federal regulations. The basis for most fire department regulations related to SCBA and IDLH environments comes from the **Code of Federal Regulations (CFR)**; specifically, CFR 29 section 1910.134 sets the requirements for many parts of the respiratory protection program including the following:

- Selection of respirators for use in the workplace
- Medical evaluations of employees required to use respirators
- Fit testing procedures
- Procedures for cleaning, storing, inspecting and maintaining respirators
- Procedures to ensure adequate air quality, quantity and flow of breathing air

In addition, CFR 29 1910.134 requires fire departments to meet the minimum requirements of what is commonly referred to as the "two in—two out" rule. This rule requires that firefighters enter the IDLH as a team, the "two in." These two must be supported by at lease two firefighters outside the hazard area, the "two out", who can help if the "two in" experience an emergency. The standard reads as follows:

> **Procedures for interior structural firefighting.**
>
> *In addition to the requirements set forth under paragraph (g)(3), in interior structural fires, the employer shall ensure that:*
>
> *1910.134(g)(4)(i)*
>
> *At least two employees enter the IDLH atmosphere and remain in visual or voice contact with one another at all times;*
>
> *1910.134(g)(4)(ii)*
>
> *At least two employees are located outside the IDLH atmosphere; and*
>
> *1910.134(g)(4)(iii)*
>
> *All employees engaged in interior structural firefighting use SCBAs.*

As a Federal regulation, CFR 29 1910.134 applies to all fire departments. The rule above does not prevent firefighters from taking immediate action, when necessary, to save a life. This rule is also supported by other documents such as NFPA 1500, *Standard on Fire Department Occupations Safety and Health Program.*

COMPONENTS OF THE SCBA

FFI 5.3.1 The major components of the SCBA are the facepiece, regulator, harness, and cylinder (figs. 10–10 and 10–11). The cylinder holds compressed breathing air for use by the firefighter. Cylinders come in a variety of construction types and capacities. Cylinders are made of steel (not typically used today), aluminum, composites such as carbon fiber (fully wrapped), and fiberglass or Kevlar (hoop wrapped or fully wrapped). Although there are exceptions, fire service cylinders are commonly grouped into two pressure categories: low-pressure cylinders, which operate with an upper limit of 2,216 psi (15,279 kPa), and high-pressure cylinders that operate up to 4,500 psi (31,500 kPa). Regardless of the pressure rating of the cylinder, firefighters should focus on the volume of air contained within. The amount of air in the cylinder is the limiting factor for a firefighter operating in an IDLH environment.

Fig. 10–10. Components of the SCBA

Fig. 10–11. SCBA bottle valve assembly

Common terminology for fire service organizations is to refer to cylinders by their rated service time (fig. 10–12). There are three common cylinder sizes in the fire service (fig. 10–13):

- 30-minute/1,200 liter/44 cubic feet (cu ft)
- 45-minute/1,800 liter/66 cu ft
- 60-minute/2,400 liter/88 cu ft

These cylinders hold enough air for a firefighter to use at a standard rate of 40 liters per minute (lpm)/1.4 cubic feet per minute (cfm) for the rated time (table 10–3). However, firefighters must understand that air consumption rates (ACRs) during firefighting operations far exceed the 40 lpm/1.4 cfm standard and can easily reach over 100 lpm/3.5 cfm. For this reason, firefighters should not expect the air in the cylinder to last for the rated service time. The minute ratings are inaccurate for fire service applications. In a study conducted by Phoenix Fire Department, and published in the article "Rapid Intervention Isn't Rapid" by Steve Kreis (*Fire Engineering*, December 2003), a "30-minute cylinder" will last a firefighter between 16.5 and 18.5 minutes. Firefighters should refer to cylinders by their standard volumes so there is no confusion between rated service times and actual fireground use. Air management and air consumption techniques are addressed later in this chapter.

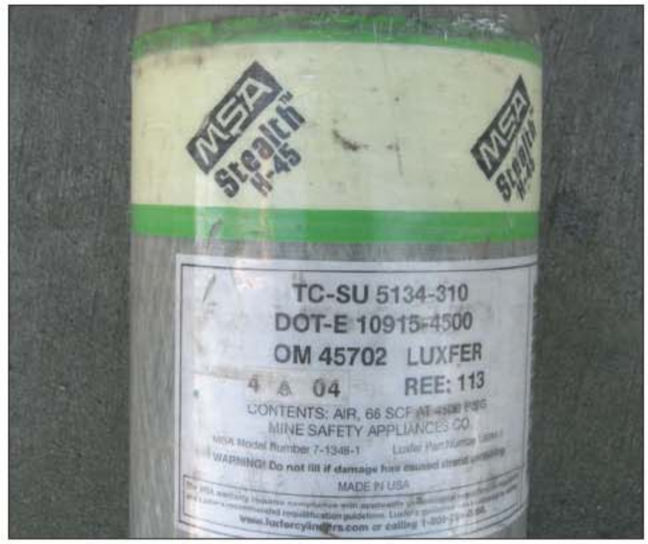

Fig. 10–12. Cylinder label that shows capacity and minute service time

Fig. 10–13. Different types of cylinders

Before each use, the cylinder should be visually inspected to ensure that it is full, has not been damaged, and has a current hydrostatic test sticker (fig. 10–14). All cylinders have a cylinder valve and pressure gauge assembly that should be checked to ensure that the cylinder is full. Although 100% of the rated capacity is desired at all times, fire departments should establish a written policy addressing the minimum acceptable capacity for a cylinder to remain in service. The user should ensure that the cylinder is above the minimum guidelines set by department policy or the SCBA manufacturer.

Table 10–3. Standard SCBA cylinder specifications

Model	Approx. duration (min.)	PSI	Weight (lbs)	Weight (kg)
374	15	3,000	3.3	1.5
602	30	2,216	6.7	3.04
639	30	4,500	7	3.18
687	30+	3,000	8.3	3.76
603	45	4,500	9.3	4.23
695	45	4,500	9.4	4.26
604	60	4,500	12.2	5.53

Fig. 10–14. This firefighter is checking for a current hydrostatic test label before filling the cylinder at an emergency incident. (Courtesy of Seattle Firefighter Local 27)

Most manufacturers mandate exchanging a cylinder at 90% or less of the rated capacity for a cylinder. Any cylinder that does not meet the requirements must be exchanged for a full one.

Visual inspection for damage to the cylinder should also be performed by the user on a daily basis. Cylinders contain an incredible amount of stored energy, and damaged cylinders should be removed from service. There are different levels of damage (fig. 10–15). Small nicks and scrapes from normal wear and tear are the least problematic and are considered Level 1 damage, which should be noted but does not require action by the user. Level 2 damage includes significant scraping or otherwise missing layers of the clear-coat protective cover. Level 2 damage requires that the cylinder be removed from service and repaired. Level 3 damage is anything greater than Level 2 and includes such items as damaged carbon fiber wrapping or significant damage caused by striking another object. Firefighters should be trained to recognize all three types of cylinder damage. Training should indicate the levels of damage that can be anticipated to distinguish normal wear and tear from more significant and dangerous damage. Check that the cylinder has been hydrostatically tested according to recognized national standards. Essentially, cylinders are subjected to specified high pressures using water as the pressurizing material rather than air. Cylinders require hydrostatic testing at 3- or 5-year intervals. Firefighters must be familiar with the requirements for the SCBA cylinders they are assigned to use. Cylinders that are beyond the accepted testing interval should be removed from service and identified for repair according to department standard practice.

The cylinder is held to the SCBA by the harness assembly. The backpack harness assembly has been the fire service standard for more than 50 years and has an excellent service history. Modern harness assemblies are rated to survive extreme conditions without failing. The back plate of the harness holds the cylinder in an upright position. A high-pressure line connects to the cylinder valve assembly by a threaded coupling to permit air flow from the cylinder to the regulator assembly. This connection includes an O-ring assembly and is particularly vulnerable to leaking and failure. Pay careful attention when connecting and disconnecting this fitting to ensure that the O-ring is present (fig. 10–16).

The harness assembly has waist and shoulder straps that connect the harness to the user like a backpack. These straps should be secured and appropriately adjusted whenever the SCBA is used. The harness assembly is designed to effectively transfer the load of the cylinder and backpack assembly to the body of the user. In addition, many harness assemblies, when fully connected, make excellent handholds to extricate unconscious firefighters from fire environments. Firefighters who operate without the waist belt or shoulder straps connected or properly adjusted increase the potential for negative consequences on the emergency scene (fig. 10–17). Although department policy should state that firefighters wear the SCBA properly, it is ultimately the responsibility of individual firefighters to operate safely.

Fig. 10–15. Examples of Level 1, Level 2, and Level 3 damage

Air is provided to the user through the **regulator assembly** (fig. 10–18). First-stage regulators reduce the high pressure (4,500 psi [31,500 kPa]) from the cylinder to approximately 100 psi (700 kPa), whereas second-stage regulators reduce it to just above atmospheric pressure. Air is provided to the facepiece at slightly more than atmospheric pressure to provide a positive pressure inside the facepiece. This ensures that the firefighter is not exposed to products of combustion in case of a facepiece malfunction or inadequate seal against the face. One style regulator is belt mounted with a low-pressure tube connecting the regulator to the facepiece. The other style is a **mask-mounted regulator (MMR)**, where the regulator connects directly to the facepiece. Firefighters should be thoroughly trained on every type of SCBA that they may be expected to use (fig. 10–19).

Fig. 10–16. Here you can see the high-pressure hose connection to the neck of the cylinder. The low-pressure alarm and the rapid intervention connection (RIC) are also visible.

Fig. 10–17. This firefighter does not have all of his SCBA straps properly connected.

Both types of regulator assemblies have **main line** and **bypass valves** attached. The main line valve allows air to flow into the regulator at a high pressure, which the regulator then reduces to just above atmospheric pressure, providing positive pressure in the facepiece. Main line valves on belt-mounted regulators are generally manually operated, while on MMRs the valve automatically opens when the regulator is placed inside the facepiece and the user inhales (fig. 10–20).

Fig. 10–18. Non-mask mounted regulator

Fig. 10–19. The MMR shown here is properly stored. When placed in service, the regulator is attached to the facepiece.

Fig. 10–20. The mainline valve on this MMR is internal and operates automatically. The bypass valve is red and can be seen mounted on the left side of the MMR.

The bypass valve allows air to go around the moving parts of the regulator and flow at increased pressure directly into the facepiece assembly. Bypass valves are usually red and are manually used only during SCBA malfunctions. Firefighters who must use the bypass valve should notify their supervisor immediately and seriously consider calling a Mayday.

The facepiece is the final component of the SCBA. The facepiece is individually sized to the user, with most manufacturers offering small, medium, or large sizes. Most facepiece assemblies offer optional equipment such as electronic voice enhancement for improved communication and **Heads-Up Display (HUD)** to assist in air management. Each firefighter must receive a fit test before initial training as well as annually to ensure proper fit. Fit testing is required by NFPA 1404 and other national standards. Fire departments should maintain a record of the annual fit test.

A **low-air alarm** is provided on all SCBA (fig. 10–21). Some take the form of a light-emitting diode (LED) lamp on an MMR and vibrating facepiece. Some SCBA manufacturers provide other types of visual and audible alarms. It is important that you determine the type of low-air alarms provided on the SCBA you will be using.

Fig. 10–21. Low air alarm on a HUD

The HUD is a great addition to the modern SCBA. The HUD allows firefighters to get information about air volume by looking at the HUD in the facepiece. While manufacturers place the HUD in different places, every HUD has a combination of lights that indicate the volume of air remaining in the cylinder by one-fourth volume increments. A full cylinder will be indicated by four green lights, 75% by three green lights, 50% by two yellow lights, and 33% by one red light. The HUD can assist firefighters in determining when they should begin to exit the IDLH environment. It is a good idea to consider beginning your exit when the 50%, or two yellow lights, marker is reached. Good air management practice will allow the entire team to exit the IDLH environment before any member reaches the 33%, or one red light, marker.

Facepiece assemblies provide air to the user from the regulator. The most common process is for fresh air to flow from the regulator through the inhalation valve across the lens to keep the lens clear of fog. The air then flows through the nose cup and is inhaled by the user. Exhaled air flows through the exhalation valve and out into the atmosphere. A properly fitted facepiece ensures that no leakage occurs around the face. The facepiece should be cleaned by the user after each use, and the lens should be inspected regularly for clarity of vision and safety. The facepiece is held to the head with a weblike harness normally consisting of three or five straps. Firefighters should be thoroughly trained to effectively and efficiently place the facepiece on the head to obtain and maintain a seal. Firefighters who use corrective lenses should consult with the SCBA manufacturer for information on placing corrective lenses inside the facepiece.

Many modern SCBA also have a built-in personal alert safety system (PASS) device, an alarm device that activates when a firefighter becomes motionless. While some firefighters still use individual PASS devices, which attach to their coat, in the past it has been shown that many firefighters failed to turn their PASS devices on. PASS devices integrated into SCBA prevent this problem: when the SCBA is turned on, so is the PASS device. PASS alarms are discussed in greater detail in chapter 9: Personal Protective Equipment.

DONNING AND DOFFING THE SCBA

FFI 5.3.1 The proper use of SCBA by a firefighter is a critical function on the fireground. If not donned properly, the unit may malfunction at a critical time. The two most common methods of donning are over-the-head and the coat methods. For both it is important that the firefighter's protective clothing be properly worn and that the SCBA be fully charged.

Over-the-head donning SKILL DRILL

The firefighter must fully open the main cylinder valve and make sure it matches the regulator gauge. With the unit being held in front of the firefighter and the cylinder valve facing away, the firefighter will lift the SCBA unit over their head and slide the unit down their back (fig. 10–22). The shoulder and waist straps are adjusted for comfort. The firefighter will then pick up their face piece, set their chin in the chin pocket of the mask, and bring the straps/webbing over their head, adjusting the straps for proper fit and comfort. Their hood is then pulled into place and their helmet is placed on their head and secured with the chin strap. The regulator/breathing tube is then attached to the mask, the gloves are put on, and the firefighter is ready for assignment.

Fig. 10–22. Over-the-head donning

Coat method donning SKILL DRILL

The firefighter must fully open the main cylinder valve and make sure it matches the regulator gauge. With the SCBA unit in front of them, the cylinder valve facing away, and the straps to the sides, the firefighter will place their dominant hand to the opposite shoulder strap near the backplate and lift and swing the unit over their dominant shoulder (fig. 10–23). The other hand and arm will be slid between the cylinder and corresponding shoulder strap. The shoulder and waist straps are adjusted for comfort. The firefighter will then pick up their face piece, set their chin in the chin pocket of the mask, bring the straps/webbing over their head, and adjust the straps for proper fit and comfort. Their hood is then pulled into place and their helmet is placed on their head and secured with the chin strap. The regulator/breathing tube is then attached to the mask, the gloves are put on, and the firefighter is ready for assignment.

Fig. 10–23. Coat method donning

Doffing the SCBA unit

SKILL DRILL

This is a reversal of how the unit was donned. The firefighter removes his gloves, disconnects the regulator from the mask, and removes their helmet and hood. The mask is removed in the following manner: Loosen head strap, if available, temple straps, chin straps, and remove the face piece. Unbuckle the waist strap and loosen the shoulder straps. While holding the shoulder strap where the regulator is attached, slide the opposite shoulder strap off your shoulder and lower the unit to the ground. Shut off the main cylinder valve and bleed of any air in the regulator by opening the purge valve. Then turn off the PASS device if it is integrated into the unit.

Installing the mask mounted regulator

SKILL DRILL

To place the MMR in service, the firefighter shall pick up their face piece and set the chin in the chin pocket of the mask. They will then fit the face piece to their face and bring the straps/webbing over their head. To adjust the face piece straps the firefighter will do so in this order: First adjust the chin straps, then the temple straps and, if available, the head strap. They will make sure the straps are pulled straight back, not outwards. They will then check for proper seal. They will then pull their hood over the straps/webbing, making sure not to dislodge the face piece. Lastly, the helmet is placed on their head and secured by the chin strap. The regulator will then be attached to the face piece as per manufacturer's recommendations.

Replacing an SCBA cylinder

SKILL DRILL

The firefighter will place the SCBA unit with the depleted air cylinder on the floor and turn off the cylinder valve. Any remaining air will be bled off using the purge valve. Disconnect the high-pressure hose from the cylinder valve and inspect the O-ring for damage. Release the cylinder from the backpack and remove the cylinder from the unit. Then place it by the refill station and take a full cylinder from the refill station. Make sure the cylinder is full by looking at the cylinder valve. Place the full cylinder in the unit's backpack and lock into place, and connect the high-pressure hose to the cylinder. *Hand-tighten only!* Then slowly open the cylinder valve and listen for leaks. Once the cylinder valve is fully opened, check the cylinder gauge with the regulator gauge to see that they match.

Replacing an SCBA cylinder being worn by a firefighter

SKILL DRILL

Have the firefighter lean over forward and remove their helmet and hood. Disconnect the regulator from the mask. Turn off the cylinder valve on the depleted cylinder and bleed the remaining air in the hoses using the purge valve. Then disconnect the high-pressure hose from the cylinder valve and inspect the O-ring for damage. Release the cylinder from the backpack, remove the cylinder from the unit by sliding it forward and away from the backpack, and place by the refill station. Take the new full cylinder and slide into the backpack, avoiding hitting the firefighter in the head. Lock the new cylinder in place, reconnect the high pressure hose to the cylinder, and open the cylinder valve and make sure the cylinder valve matches the regulator valve. Notify the firefighter that the cylinder exchange is complete and they may return to service.

Many modern SCBA also have a built-in PASS device, which activates when a firefighter becomes motionless. While some firefighters still use individual PASS devices that attach to their coat, many firefighters in the past have failed to turn their PASS devices on. PASS devices integrated into SCBA prevent this problem—when the SCBA is turned on, so is the PASS device. PASS alarms are discussed in greater detail in chapter 9: Personal Protective Equipment.

ACTIVITIES WHILE IN SCBA

SKILL DRILL

The SCBA is worn by firefighters at all structural fires and many other types of emergencies including hazardous materials, confined spaces, structural collapses, and some emergency medical alarms. It is important for firefighter trainees to have the opportunity to operate in the SCBA in enough nonemergency capacities to prepare for whatever an emergency scene may present. Thorough training includes practice in advancing hoselines, climbing ladders, crawling through windows, and many other activities that the firefighter can be expected to perform on the fireground.

Firefighters are often called on to perform a variety of tasks. To perform these tasks, the firefighter must be competent enough in the operation and use of the SCBA so that the firefighter can concentrate on the other skills. Take the example of a **primary search**. If a firefighter enters the structure from a ladder, the ladder must be taken from the apparatus, carried to the fire building, spotted and raised, and finally climbed by the firefighter to make access through a window (fig. 10–24).

Fig. 10–24. Firefighters putting up a ladder at a fire have many things to consider. Wearing the SCBA should not negatively affect the ability of a well-trained firefighter to perform basic tasks.

The firefighter then must perform a search of the fire room or fire floor, communicate within the crew, and perhaps even talk on the radio. If the firefighter is accessing the building through the front door, the firefighter may need to perform forcible-entry skills, assist with the hand line advancement, and then proceed with the search. In both examples the SCBA is expected to be a part of the firefighter's protective ensemble. The firefighter must be comfortable and confident enough with using their SCBA to safely and effectively perform the tasks. This level of SCBA comfort and confidence comes through regular and realistic training exercises. This level of SCBA comfort and confidence is maintained over a career through regular and realistic training exercises.

AIR CONSUMPTION RATES AND FACTORS THAT AFFECT THE DURATION OF THE AIR SUPPLY

Firefighters operating in an IDLH environment are limited by the amount of air they bring with them in their SCBA. Firefighters must be trained to exit the IDLH environment before the activation of the low-air warning alarm. To do this effectively, each firefighter must be aware of the amount of air they use in a given time or their **air consumption rate (ACR)**. The ACR will have a big impact on the duration of the air supply and can help firefighters and fire officers balance the needs of the incident or assignment against the ACR and other factors. Some of the factors that must be considered are outlined in the following text:

- Fitness:
  - The size, weight, and overall aerobic fitness of a firefighter affects the duration of the air supply and the ACR. As a rule, smaller firefighters use less air in a given time than larger firefighters given the same workload. Aerobically fit firefighters generally use less air than the same size firefighter who is unfit.
- Nature of the work being performed:
  - The harder the work performed, or the more physical exertion required by a firefighter, the more air the firefighter uses. This applies independent of other factors. Given an

assigned task, there are often higher workload positions within a crew. Understanding the ACR for individual members of the team can assist the company officer in making assignments to maximize team effectiveness related to the ACR.

- The environment where the work is being performed:
  - Hot, dark, smoke-filled rooms create physical and emotional stress on the human body. Although some improvement to the ACR is expected in firefighters with experience, it is important to understand the physiological and psychological stressors that apply in IDLH environments. Firefighters should be aware of their own physical reaction to environmental stressors and train themselves to control their respiratory rate and emotional state during times of high stress.
- The effects of protective clothing and repeated work cycles:
  - The modern PPE, or bunker gear, provides a great degree of protection from fire and other thermal effects. The downside to this level of protection is the encapsulation of the member within the *greenhouse* created by the sweat and heat of their own activity. Fire departments should address the ratio of work cycle to rest cycle requirements for firefighters operating in full PPE and SCBA.
- The duration of a firefighting operation inside an IDLH environment:
  - The amount of air inside the cylinder when entering the IDLH environment affects how long you can operate. The more air you start with, the longer your operating time will be. Fire department policy should address the minimum pressure, or volume, allowed before committing to an IDLH environment. In no case should this be less than 90% of the rated capacity of the cylinder. Firefighters have died after entering an IDLH environment with a cylinder that was less than the minimum required.
- How far firefighters travel inside the IDLH environment and the distance and time required to reach an area of safety:
  - Because a firefighter is required to exit the IDLH environment before activation of the low-air warning alarm (33% of the capacity of the cylinder), the firefighter must be aware of how long it takes to reach the area of safety, how much air that travel time uses, and how this affects the assigned activity. Having a clear understanding of how and when you will exit the IDLH environment allows the firefighter and the team to perform effectively in the firefight. In addition, the company officer can more easily identify whether the team can complete their assigned objective.
- Company officers coordinating the activity of the team:
  - Getting the team to complete the assigned task effectively, exit in a coordinated and safe manner, and maintain an appropriate margin for safety are necessary components of the company officer's responsibility. To do this effectively, the company officer needs information and interaction with the members of the team. The company officer also coordinates with the incident commander to arrange for a crew to relieve the team inside the IDLH environment if the team cannot meet their assigned objective and safely exit the space. This responsibility requires the company officer to know and understand the ACR for each team member and how this applies to the current team assignment. Improved understanding of the ACR as well as the factors that affect the duration of the air supply lead to improved situational awareness for all members of the team.

The ACR is a fluid factor for a given firefighter or team within an incident and over a career. For example a veteran generally experiences less stress than a rookie on the fireground. Understanding how the ACR, incident, and team members interrelate can be maintained through regular and effective training exercises with the SCBA. Well-trained firefighters, working in well-led teams, perform more safely and make their air last longer.

THE AIR MANAGEMENT PROGRAM

SKILL DRILL

FFI 5.3.1 Fire departments are required by NFPA 1404, *The Respiratory Protection Training Standard,* to have an **air management program (AMP)**. The AMP is the foundation for understanding the relationship between the ACR, the factors that affect the duration of the air supply, effective operation of the firefighting team in an IDLH environment, and the safe exit of the team prior to the low-air warning alarm activating.

All SCBA are equipped with a low-air warning alarm. This alarm is designed to indicate to the wearer that they have used all of the air designated for operation in the IDLH environment and are now consuming the emergency reserve. Low-air warning alarms are required to activate when the cylinder reaches 33% of the rated capacity. Manufacturers have created various types of low-air warning alarms: from a ringing bell, to a vibrating alarm, to an electronic beep or whistle. Firefighters must be able to recognize the sound of the low-air warning alarm for each type of SCBA they may be required to use or hear at an incident scene. A firefighter's survival may depend on their ability to recognize, or have others recognize, the activation of the low-air warning alarm on the incident scene.

Each department is required to have an AMP that should include the following three directives for firefighters using SCBA:

1. Firefighters must exit the IDLH environment before consumption of the emergency reserve begins.
2. The low-air warning alarm indicates that the firefighter is using the emergency reserve.
3. Activation of the low-air warning alarm is an "Immediate Action Item" for the individual and the team.

Another way to look at this requirement is to simply follow the **rule of air management (ROAM)**. The ROAM states:

> "Know how much air you have, and manage that air, so that you leave the hazard area BEFORE the low-air warning alarm activates."

- Know what you have.
- Manage it as you go.
- Exit before the alarm.

The firefighter functions as a member of a team while operating in and SCBA. The team leader must understand the components of the AMP and how each applies in different situations. In all cases the team leader is required to ensure that the team follows the ROAM and exits the IDLH environment prior to the activation of the low-air warning alarm. To accomplish this, the team leader must coordinate the activity of the team in conjunction with the ACR and the air management policy. The team leader may consider assigning roles on the team based on the individual ACR (fig. 10–25).

Fig. 10–25. Company officers of the roof ventilation team quickly review assignments before going up the ladder. Understanding the high and low workload positions during a roof operation increases the effectiveness of the team. (Courtesy of Yukari Horikawa)

The team leader may rotate personnel from positions of high work to positions of low work to ensure that air use is equalized within the team. Team members should understand how to use **controlled breathing** techniques. Team leaders must have an area of safety identified (the exit out of the hazard area), estimate travel time and distance to the area of safety, and determine when the team must begin to exit to reach the area of safety before the activation of the low-air warning alarm.

IV. Controlled Breathing Techniques (1–4)

A. Breathing must be kept on a conscious level. Subconscious patterns result in breathing only through the mouth or nose

1. Nose breathing results in
    a. Short breaths
    b. Lungs not filled to capacity

2. Mouth breathing results in
    a. Rapid breathing
    b. Body cannot take full advantage of oxygen before exhalation

B. Suggested Patterns

1. In through nose - out through mouth
    a. Easy to learn and remember
    b. Close to normal pattern when speaking
    c. Technique
        1) Breathe in slow and deep
        2) Hold in lungs 3–4 seconds for maximum oxygen/carbon dioxide exchange

2. In through mouth - out through nose
    a. Allows for good air exchange without holding breath
    b. Techniques
        1) Inhale rapid and full
        2) Exhale slowly
        3) Best method for strenuous work

3. Five-second count method
    a. Technique
        1) Inhale for 5 seconds using either of first two methods—slowly and fully
        2) Hold for 5 seconds
        3) Exhale for 5 seconds
        4) Hold for 5 seconds
        5) Repeat cycle
    b. Best for short rest breaks

4. Skip breathing
    a. Emergency only - for conservation of air
    b. 30-minute SCBA may be extended to 2 hours
    c. Technique
        1) Inhale fully
        2) Hold breath for normal exhalation time
        3) Take additional breath before exhaling
        4) Exhale slowly
        5) Repeat cycle
    d. Important to remain mentally and physically calm

COURTESY: British Columbia Fire Training Officers Association. http://www.bcftoa.com/private/docs/training/scba.html

Exiting the hazard area prior to activation

The requirement that firefighters be trained in the AMP and exit the IDLH environment prior to the activation of the low-air warning alarm is new to the fire service and began with the adoption of the 2006 version of NFPA 1404. This practice is designed to improve the safety of firefighters wearing SCBA and provide a margin for safety in case of an accident inside the hazard area. Managing air and exiting the IDLH with a margin for safety can help prevent firefighter emergency and Mayday situations. Although rapid intervention teams (RITs) are a required and important fire scene resource, prevention of Mayday situations is always preferable to relying on intervention capabilities at the incident scene.

To exit the IDLH safely, firefighters must operate as a team. The foundation for an effective team is training before the run (event). When operating, always ensure that other members of your crew and other firefighters are not endangered by your activities. Work within the team and respond to the company officer's direction to make the team successful. Maintain your own situational awareness, including air supply and ACR. Maintain team accountability, including the location of, and distance to, your exit and the amount of air required for the team to get there safely. Complete the assigned activity and recognize when your air supply or other factors may prevent you from completing your assignment. Communicate within the team and with the incident commander whenever you have completed your task, are unable to complete your task, recognize that the fire conditions are changing, or identify fireground tasks that need to be completed. Begin exiting the hazard area so you reach the area of safety before the activation of the low-air warning alarm.

On occasion, a firefighter or team may stay too long in the hazard area and activate a low-air alarm on the way out. These situations require immediate action by the individual and the team. At a minimum, department policy should require a firefighter with a low-air alarm to contact the incident commander; identify the team; communicate the situation, the projected exit time, and location; and advise if any additional assistance is needed. Be realistic about your situation. This is no time for bravado. You may literally be betting your life on this decision. If there is any chance you will not exit before your air is exhausted, request activation of the rapid intervention team (fig. 10–26). The low-air alarm emergency should be included in fire department policies addressing firefighter emergency, urgent, or Mayday calls.

Fig. 10–26. Incident commanders can only provide assistance when they know you have a problem. Communicate the Mayday early so the appropriate resources can be sent. (Courtesy of Seattle Firefighter Local 27)

SCBA FAILURES

SKILL DRILL

The modern SCBA is a reliable piece of safety equipment when it is properly maintained. Regardless of the reliability, situations occur when the SCBA partially malfunctions or fails outright. The potential for SCBA failure is one reason firefighters must maintain a margin for error with effective air management technniques while operating in an IDLH environment.

One common cause for equipment failure is the abuse or misuse of equipment. Many photographs or videotapes of fire scenes across America show firefighters who are abusing their SCBA by wearing it improperly. The waist belt holds the regulator assembly for most SCBA. Wearing the backpack without the waist strap attached causes the regulator to receive more abuse than with the waist belt attached. In addition, the failure to connect the SCBA's straps and belts decreases overall safety and should not be allowed. Many photographs show firefighters who have removed the MMR from the facepiece but have not stored it on the waist belt. This practice allows dirt and moisture to enter the regulator and increases the potential for failure (fig. 10–27).

Fig. 10–27. Two SCBA temporarily stored on the ground with the regulator exposed. Improper storage can result in water or debris entering the regulator assembly and causing a malfunction. Always store the SCBA with the regulator protected.

Unapproved equipment attached to the SCBA can cause the device to fail. First among the list of unapproved equipment is the **cheater** that has been used by firefighters for years. The cheater is an unapproved modification to the SCBA that consists of a tube attached to the inhalation valve on the facepiece. The cheater allows a firefighter to choose between breathing the clean air provided by the SCBA or breathing the contaminated air of the fire scene. This modification violates all safety related to the SCBA and cheats only the firefighter and the firefighter's family. In this way firefighters cheat themselves out of a long life. In this way firefighters cheat their daughters out of a walk down the aisle. In this way firefighters cheat their grandchildren out of a good spoiling. Unapproved equipment should *never* be attached to the SCBA, and fire departments should deal with cheaters effectively. The firefighter should never consider attaching the cheater to their SCBA or their reputation.

The practice of **buddy breathing** is another way the user can cause the SCBA to fail. The practice of buddy breathing should not be confused with using the RIC fitting or other devices attached to the SCBA for the purpose of providing emergency assistance to a firefighter experiencing a low-air or out-of-air emergency. Buddy breathing in this context is the practice of sharing the SCBA facepiece with a civilian or other firefighter. This practice should not be condoned or practiced in any way. Firefighters must maintain their respiratory protection to ensure that they can guide an affected civilian safely from the fire building. Proper air management practices can prevent situations where another firefighter experiences a low-air or out-of-air emergency.

The best way to ensure that your SCBA provides excellent and reliable service is to ensure it is properly maintained, serviced at appropriate intervals, and checked prior to use. Training, record keeping, and effective leadership on and off the fireground prevents SCBA failure as well as the attendant urgent, Mayday, low-air, or firefighter fatality situation (figs. 10–28 and 10–29).

DAILY CHECKS – EVERY DAY

Cylinder:
-Cy inder gauge reads above 4050.
-Cy inder with less than 4050 will be replaced.
-Check condition of the cy inder.
-Damaged cy inders sha l be removed from service.
-Cy inder band is fu ly tightened and latch locked.
-Rubber bumper is in place.

Low Pressure Audi Alarm:
-Coupling nut is hand tight at the cylinder valve.
-Bell clear of obstructions, dirt or debris.
-Quick fill cover is in place.

Pressure Hoses and First Stage Regulator:
-Check for tight fit at the bell and the regulator.
-Check for physical damage to the hose.

Second Stage, Mask Mounted Regulator:
-Follow hose checking for physical damage.
-By-pass knob closed finger tight.
-Regulator free of moisture and debris.
-Store in belt mounted holder.

ICM 2000 / Pressure Gauge:
-Open Cylinder Valve fully to charge system.
-Listen for Audi-alarm bell and ICM 2000.
-Listen for air leaks.
-Check that cylinder gauge and ICM 2000 pressure gauge read within 10% psi of each other.
-Close Cylinder Valve and bleed pressure from system using bypass until low pressure bell sounds at 1175 psi.
-Turn off alarm by pressing yellow switch twice in succession.
-Check that ICM 2000 connector nut is tight at swivel.
-Quick-fill cover is in place.

Backpack Harness and Carrier:
-Check that straps are fully extended and buckles work.
-The quick-fill hose with protective pouch in place.
-Check for cracks or deterioration in the frame.

WEEKLY – AFTER YOUR FOUR OFF

Face piece:
-Lens clean and free of cracks.
-Four adjustable head straps have not deteriorated.
The nose cup is in place and free of debris.
-Nose cup inhalation valves installed properly.

Pass Device and ICM 2000 Check:
-Don SCBA backpack.
-Open Cylinder Valve fully to charge system.
-Stand motionless until warning tones sound, move PASS to cease tones and assure proper operation of motion sensor.
-Remain motionless and let system go into fu l alarm.
-Reset by pushing yellow button twice in succession.
-Manually operate ICM 2000 Alarm by depressing red emergency alarm button. Reset with yellow button.
-Check operation of backlight by pressing green button.
-Operate Bypass and listen for air flow, then close.

Operation and System Check:
-Don faceplece.
-Check faceplece seal by holding palm of hand over inlet connection. Inhale, holding breath for 10 seconds.
-Keep inlet covered, breath out to test exhalation valve.
-Connect MMR to faceplece and inhale sharply to start air flow.
-Turn on amplifier and verify operation. Turn off.
-Verify HUD operational with 4 green lights.
-Disconnect MMR.
-Close cylinder and check that the alarm pressure gauge does not show a reduction in pressure, for 30 seconds, due to leaks.
-Bleed off pressure, holding face piece close to HUD sending unit and verify that HUD and ICM 2000 low air lights flash at 1175 psi. then reset ICM 2000.
-Place backpack and faceplece on vehicle ready to respond.

SUNDAY
-Lubricate second stage regulator, be t mounted storage unit and face piece with Christo-lube lubricant.

TRAINING
Video instructions for performing the checks on this sheet are available on the in-web under Training/videos.

DATE	REMARKS – REPAIRS	DATE REPAIRED

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Fig. 10–28. A sample of an SCBA maintenance document. This side of the document lists the minimum daily and weekly checks that must be performed and repair notes.

DAILY AND WEEKLY MASK CHECK

DATE	MASK NUMBER							DATE	MASK NUMBER						
1								16							
2								17							
3								18							
4								19							
5								20							
6								21							
7								22							
8								23							
9								24							
10								25							
11								26							
12								27							
13								28							
14								29							
15								30							
Company No.______ Month______ 20____								31							

Form 029 (9/2003) Indicate "OK" or "R" for repair

Fig. 10–29. This side of the document records the identity of the person who completed the daily or weekly check.

FIREGROUND NOTE

Cheating is an act of lying, deception, fraud, trickery, imposture, or imposition. Cheating characteristically is employed to create an unfair advantage, usually in one's own interest and often at the expense of others.

EMERGENCY PROCEDURES FOR SCBA FAILURE

SKILL DRILL

FFI 5.3.1 FFI 5.3.5 Firefighters should be trained in and regularly practice for failures of the SCBA. The SCBA is a piece of mechanical equipment. No matter how well built, maintained, or checked, failure is not only possible, *it is predictable.* Although SCBA failures are rare, they do occur. Firefighter training should include the potential causes for SCBA failure and specific procedures to follow for different failure situations. Each type of SCBA should include specific emergency procedures in the owner's manual. Fire departments should ensure that each firefighter can demonstrate all emergency procedures associated with each SCBA that may be used. Although it is impossible to address all of the emergency procedures for all the manufactured styles and types of SCBA, some failure considerations are identified in the following text and a basic procedure for a cracked facepiece can be found in fig. 10–30.

One category of problems can be attributed to operating the SCBA in low temperature situations. Firefighters should be aware that low temperatures can cause freezing and icing problems. Icing can occur on the cylinder. The release of compressed air from the cylinder causes the remaining air to cool. The cooling properties of expanding air can also cause icing to occur on the hoses connecting the cylinder to the regulator assembly. In some SCBA, this icing can negatively affect the low-air warning alarm and cause a partial or complete malfunction. Such a malfunction can cause a firefighter who is not practicing air management to run completely out of air in the hazard area and may lead to significant injury or death. Mechanical failure like this is another reason firefighters must manage their air.

Low-temperature situations can also cause fogging or icing of the facepiece. The design of the positive-pressure facepiece directs the incoming air across the front of the glass lens to minimize internal fogging. The cold air causes the glass to become cold, which can increase the tendency for moisture to condensate on the outside of the facepiece obscuring the vision of the firefighter. Fogging of this type can be easily dealt with by wiping the facepiece with the gloved hand. Firefighters should be aware that this may scratch the glass or deposit debris on the lens. Anti-fogging compounds can be used to minimize the effect of internal or external fogging within manufacturers' specifications.

MINOR CRACK OR LEAK IN FACEPIECE

- Don't PANIC. The benefits of remaining calm cannot be emphasized enough when dealing with an emergency procedure.
- Leave facepiece on. The facepiece continues to provide protection to the lungs, eyes, nose, mouth, and skin. With a minor leak, leaving the facepiece on provides the best option.
- Place hand on facepiece/regulator and press against face. A leak from the facepiece from a minor crack will act similar to an inadequate fit of the facepiece seal. Due to the positive pressure of the system, excess air will leak out from within the facepiece. Pressing the facepiece against the face helps to alleviate the option that air is leaking between the skin and the seal. It helps to ensure that a leak is coming through the facepiece itself.
- Conserve air by covering crack with hand. The air coming out of the regulator is slightly above the atmospheric pressure outside of the facepiece. This helps to ensure that there is a positive pressure within the facepiece and thereby neglecting contaminated air from entering through a small hole or crack. However, if the crack/hole is not covered, the air in the cylinder is depleted at a faster rate.
- Notify officer and leave with another member. Consider your department's policy on accountability and Federal or State OSHA laws, when a member enters or leaves an IDLH.

MAJOR CRACK OR LEAK IN FACEPIECE

- Continue to cover damaged area.
- Press the manual shutoff after each breath. If air still seems to be leaking out, excess air is being lost while a hand covers the crack/hole. Engage the manual shutoff after each breath. This will thereby limit the amount of air from the cylinder that will be lost due to the positive pressure of the system.
- If manual shutoff will not release on inhalation, control air flow using purge or bypass valve. If a gloved hand over the leak does not cover enough of the crack/hole, the inhalation may not be strong enough to activate the flow of air out of the regulator. Therefore, continue to have the manual shutoff engaged and utilize the purge or bypass valve to allow enough air to enter the facepiece.
  A partial opening of the purge or bypass valve may be enough for a breath, then close the valve after each breath. SCBA manufactures have their purge or bypass valves on different sides. Check yours to ensure what hand will cover the leak and what hand will operate the valve.
- Notify officer and leave area immediately with a partner. Consider your department's policy on the urgency of these two emergencies in the use of your PASS and the necessity of a Mayday radio transmission.

Fig. 10–30. Cracked facepiece emergency procedure (Jarod Blake, FDNY, FDIC 2007 instructor)

Low temperatures can also cause high-pressure hose leaks with the contraction of the metal. Firefighters should take extra care to ensure hose connections are tight enough to prevent leaking during low temperatures but still loose enough to operate effectively when warm. A leaking low- or high-pressure fitting can be identified by listening carefully when charging the system with air during the daily check. Leaking SCBA that cannot be fixed should be placed out of service and identified for repair. Unexplained increases in the ACR for a firefighter may also indicate leaking. A leaking hose is cause for immediate exit from the hazard area.

High temperatures can present challenges to the firefighter using an SCBA (fig. 10–31). Although the ambient air may be hot, the breathing air supplied to the firefighter is relatively cool. This occurs because the physical properties of compressed air cause it to cool as it expands. Firefighters must be aware that the temperature around them may be quite high even though they are comfortably breathing fresh air. Training programs should include information so that firefighters can accurately identify when high temperatures exist in the IDLH environment and how to deal with them effectively when they occur. This training should include situations where rapid temperature changes can be considered indicators of extreme fire behavior, such as rollover or flashover, and the potential for serious injury or death.

Many SCBA include built-in or add-on communications devices. Communications devices often improve the ability to talk within the team or over the radio (fig. 10–32). They can present their own challenges and limitations. For example, if many devices are in the same area or the operator is in an area with thick or reinforced walls, the transmission may be compromised. It is also possible for feedback to occur if there are many communications devices within the same small area at a fire. The ability to communicate effectively is critical to fireground safety. All firefighters should be trained and familiar with any communications device that is provided for use during an emergency. Firefighters should also understand alternate techniques to improve communication through a radio microphone. Many firefighters have success by placing the microphone against the throat or against the facepiece glass while talking. One factor that will always improve communication is a calm and steady voice.

Fig. 10–31. Firefighters exposed to high-temperature fire gases while making entry or operating in an IDLH environment are well protected when they use the SCBA properly. (Courtesy of PM Brian Smith, Seattle, Washington, Fire Department)

Fig. 10–32. An example of a communication device attached to the facepiece. Firefighters should be well-trained in how to communicate effectively while operating in their SCBA. (Courtesy of Mine Safety Appliances)

Out-of-air situations, although rare, can be fatal. Firefighters should avoid out-of-air situations at all costs. It is possible to prevent out-of-air situations through good teamwork, good situational awareness, good training, and good air management practices (ROAM). Low-air situations should be considered an emergency and an urgent or Mayday should be transmitted. Firefighters' training should include methods to conserve air during low-air emergencies to maximize survival time while finding an exit or awaiting the RIT team. In all cases consider reducing physical activity to reduce respiratory demands. These can include the following:

- **Skip breathing:** Take a small breath, hold 5 seconds, take in another breath, hold 5 seconds, exhale, repeat.
- **Breath control:** Calm your mind and focus on restricting air intake while reducing physical activity.

- **Use the Reilly Breathing Technique:** Breath in slowly, exhale slowly while humming a calming song. This may also help calm your mind to help breath control.

In the rare circumstance that a firefighter runs completely out of air, the Mayday should already have been called and help should be on the way. Once you are out of air your survivability is in jeopardy. Clear thinking and calm action may make the difference. Remain calm, and do not give up. Whenever possible, leave your facepiece on. This will allow the RIT team to connect to your universal RIC connection and provide breathable air as quickly as possible.

Here is a list of last resort options for dire situations:

- Leave the facepiece on, remove the regulator, and "filter breathe" the ambient air. Use your hood or glove to filter and possibly cool the smoke. Breathe as shallow as possible. Many fire service instructors will advise you to keep low to the ground. However, this may be a bad option if the carpet has been heated to the point that it is off-gassing. If the carpet is off-gassing, the primary component will be hydrogen cyanide. One breath may be enough to incapacitate.
- Attempt to find areas where there is less contaminated air to breathe. These may include toilet tanks, wall or floor void spaces, washers and dryers, windows, ventilation shafts, and sewer vent pipes.

Use of universal rescue connection assemblies

All NFPA 1981–2002 approved SCBA come equipped with a URC assembly fitting. The **universal rescue connection (URC)** is a male quick-fill inlet found on the back of the SCBA by the cylinder valve. The URC is for use by RICs for emergency filling operations only. Some SCBA manufacturers also equip their SCBA with a shoulder-mounted quick-fill system.

Fire departments must develop and use standard operating procedures (SOPs) for URC use by RICs or RITs as well as for emergency operations. Firefighters must understand how to use the URC, under what circumstances to use the URC, and when they should not use the URC. Of course, a solid hands-on training program focusing on the URC and rapid intervention is critical to the success of firefighters using the URC correctly.

The following is a step-by-step method for using the URC in emergency situations. It should be noted that RICs must use a separate air supply (a secondary air supply), such as a **rescue air kit (RAK)**, which is a full air cylinder, a quick-fill hose, and an extra facepiece. These kits can be purchased from the SCBA manufacturers. *NIOSH does not approve the use of the URC assembly to transfer air from the cylinder of one SCBA to another SCBA. Failure to follow this warning can result in serious injury or death.*

1. To attach the quick-fill system hose of the secondary source, such as a RAK, to the URC:
   - Turn the secondary air source on, fully opening the RAK cylinder valve.
   - Remove the rubber dust cap from the male inlet fitting on the URC found on the back of the SCBA of the firefighter needing air. Be sure that the firefighter's SCBA cylinder valve is fully opened.
   - Remove the rubber dust cap from the female fitting on the quick-fill hose.
   - Push the female fitting of the quick-fill hose on the male fitting of the URC until it snaps into place. Pull on the hose to be sure the fitting snapped into place. Filling begins when the female fitting is snapped on the URC.
   - After approximately 45 to 60 seconds, pressure equalizes between the secondary air source (such as the RAK) and the SCBA of the firefighter needing air.
2. Compare the SCBA pressure gauge of the firefighter receiving air to the secondary air source cylinder gauge. If the readings are the same, the pressure is equal.
3. Disconnect the quick-fill hose after the transfill is complete.
4. Remove the firefighter who needed the emergency air outside the hazard area as quickly as possible.

INSPECTION AND MAINTENANCE

Basic maintenance on SCBA is very important. If the unit is not checked on a regular basis, there is the chance it will fail at a critical moment on the fireground. To inspect a cylinder, the following is performed. Remove the unit from its holder or container. Check the straps and backpack for any excessive wear or damage. The high-pressure hose between the regulator and the cylinder should be checked for any damage or excessive wear. Next is the cylinder. This outside should be checked for damage to the fiberglass or metal. Make sure that there is no damage around the cylinder valve. The cylinder valve should read full. Open the cylinder valve and check it against the regulator valve. If the unit is an MMR check the low pressure hose from the regulator to the pressure reducing device. Activate the integrated PASS device, if available. Connect the regulator to the face piece and take several breaths. Once this is complete close the cylinder valve, purge the air from the system and make sure the low pressure alarm activates. Close the purge valve and restore to service.

Cleaning an SCBA

SKILL DRILL

FFI 5.5.1 In order for firefighting equipment to work properly, it must be maintained and cleaned on regular basis. To clean an SCBA unit, do the following. Remove the face piece from the regulator and place on the side. Then remove the cylinder from the SCBA harness. Rinse all parts of the unit with clean water to remove any debris. A soap and water solution should be used to scrub the cylinder and harness with a still bristle brush. Rinse the harness and cylinder off and set aside to dry. To clean the face piece, first mix a solution of mild soap and water in a 5-gal (19 L) bucket. Place the face piece in the solution and allow to soak. Clean the regulator using the solution and a soft-bristle brush, making sure soap doesn't get inside the regulator. Rinse the face piece and regulator with clean water and set aside to dry. When components are dry, reassemble and inspect the unit before placing back in service.

Refilling a bottle with a cascade system and a compressor system

SKILL DRILL

Before any cylinder is refilled, there is certain information that needs to be obtained about the cylinder. The necessary forms to be used should be spelled out in the department SOPs. Information to be filled out will be cylinder type, required air pressure to be placed in the cylinder, cylinder serial number and identification number, the hydrostatic test date of cylinder, date of the refill. Once this is recorded, the operator needs to check the condition of the cylinder, date of cylinder manufacturer, hydrostatic test date. After these items have been checked, the cylinder can be filled. To fill the cylinder, place the air cylinder in the shielded refill station, then fill the cylinder slowly to prevent overheating. Once you are sure the cylinder is full, but not over-pressurized, remove the cylinder from the refill station.

NOTES

1. Gagliano, Mike, Casey Phillips, Phil Jose, and Steve Bernocco. *Air Management for the Fire Service.* Tulsa, OK: PennWell, 2007.
2. Wallace, Deborah. *In the Mouth of the Dragon.* Garden City Park, NY: Avery, 1990.

LESSON FROM THE FIREGROUND

The first arriving company observes heavy smoke pushing from the first floor apartment of a two-story garden style apartment complex as they turn the corner. As the apparatus pulls to the front of the building a woman with a baby in her arms appears in the window of the second-floor apartment above the fire apartment. The officer jumps from his seat on the apparatus and races into the building to make a quick rescue. He thinks he can hold his breath long enough to make the grab and exit quickly. The unfortunate reality of this poor decision is readily apparent as the officer is seen stumbling out of the doorway gasping for air.

One of the firefighters from the first due unit has donned an SCBA while the officer ran into the building. He passes the officer who is stumbling out of the doorway and quickly makes his way to the trapped occupants. The SCBA equipped firefighter is able to quickly remove the woman and her baby to safety. Once outside, the firefighter sees the company officer on the rear tailboard sucking on an oxygen mask and being readied for a trip to the emergency room. The lesson is indelibly engraved in the firefighter's memory—always take the time to don the SCBA.

QUESTIONS

1. Firefighters are provided a known quality of breathable air for operations in IDLH or potentially IDLH. What does IDLH stands for?
2. The IDLH environment is produced by the combustion of the___________.
3. The combination of _____ and _____ substances is IDLH for firefighters.
4. What is likely to be found in abundance compared to any other product in today's homes?
5. What gas is a common cause of death to firefighters?
6. The respiratory tract is protected by SCBA use from toxic and ___________ gases.
7. The leading cause of firefighter deaths is _____________________.
8. When should medical screening start? How often should it be done?
9. When a 2,216 psi bottle reaches ___________ psi, it should be recharged. When a 4,500 psi bottle reaches ____________ psi, it should be recharged.
10. How often do cylinders have to be hydrostatically tested?
11. Fit testing is required by NFPA _____________.
12. Low-air alarms are required to sound when cylinders reach _______ %.
13. ROAM stands for __________ ______ __________ __________.
14. ROAM states that you should leave the hazard area ________________ your low air alarm activates.
15. Skip breathing is when you take a small breath, hold for ___ seconds, take in another breath, hold for ___ seconds, exhale, and repeat.