


**Verdugo Fire Academy**  
*... more than fighting fires*  
**SELF CONTAINED BREATHING APPARATUS**

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**Respiratory Protection**

- The interior atmosphere of a burning building is considered immediately dangerous to life and health (IDLH).
- Firefighters must be proficient in using SCBA before engaging in interior fire suppression activities.
- Using SCBA confidently requires practice.

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**Respiratory Hazards of Fires**

- Four primary respiratory hazards of fires:
  - ◆ Superheated air and gases or elevated temperatures
  - ◆ Smoke and by-products of combustion
  - ◆ Oxygen-deficient atmospheres
  - ◆ Toxic atmospheres

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### Hazards Found

- Confined space
  - ◆ Oxygen deficiency
- Hazardous materials release
  - ◆ Toxic atmosphere
- Fire
  - ◆ Generally all four are present



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### Smoke

- Smoke particles are unburned, partially burned, and completely burned substances which can be toxic or irritating.
- Smoke vapors, or small droplets of liquids, can be toxic or irritating.
- Toxic gases in smoke include:
  - ◆ Carbon monoxide
  - ◆ Hydrogen cyanide
  - ◆ Phosgene



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### Smoke

- The suspension of small unburned particles:
  - ◆ Carbon
  - ◆ Tar
  - ◆ Dust
- An irritant to the respiratory system
- May result in
  - ◆ Pulmonary edema
  - ◆ Death



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## Oxygen Deficiency

- Air is normally about 21% oxygen.
- Oxygen deficiency in an enclosed area occurs in two ways:
  - ◆ Fire consumes large quantities of the available oxygen, decreasing the concentration of oxygen.
  - ◆ Fire produces large quantities of other gases, which displace the oxygen that would otherwise be present.

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## Oxygen Deficiency

**Table 2-3 Physiological Effects of Reduced Oxygen Concentration**

Oxygen Concentration	Effect
21%	Normal breathing air
17%	Judgment and coordination impaired; lack of muscle control
12%	Headache, dizziness, nausea, fatigue
9%	Unconsciousness
6%	Respiratory arrest, cardiac arrest, death

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## IDLH

- Immediately dangerous to life and health
- National Institute for Occupational Health and Safety's (NIOSH) definition of IDLH condition:
  - ◆ One that "poses a threat of exposure to airborne contaminants when that exposure is likely to cause death, immediate or delayed permanent adverse health effects, or prevent escape from such an environment"

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**Ppm**

- Parts per million
- Number of molecules of contaminant found in 1,000,000 molecules of air
- 1 ppm is equivalent to ratio of 1¢ to \$10,000



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**Effects of Exposure**

<ul style="list-style-type: none"> <li>■ Physical Effects of Exposure           <ul style="list-style-type: none"> <li>◆ Eye irritation</li> <li>◆ Reduced vision</li> <li>◆ Cough</li> <li>◆ Headache</li> <li>◆ Pulmonary edema</li> <li>◆ Asphyxiation</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>■ Mental effects of exposure           <ul style="list-style-type: none"> <li>◆ Inability to reason</li> <li>◆ Irrational behavior</li> <li>◆ Confusion</li> <li>◆ Unconsciousness</li> </ul> </li> </ul>
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**Cumulative Effects of Exposure**



- Lung damage
  - ◆ Emphysema
  - ◆ Bronchitis
- Cardiac complications
  - ◆ Heart attack
  - ◆ Dysrhythmia
- Cancer
- Death

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### Conditions Requiring SCBA

- Firefighters encounter four common respiratory hazards at emergency scenes: oxygen deficiency, elevated temperatures, smoke, and toxic atmospheres. Each of these can have both physical and mental effects on the firefighter if proper respiratory protection precautions are not taken. Exposure to respiratory hazards can have long-term cumulative effects on firefighters.

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### Conditions Requiring Protection

- SCBA must be used:
  - ◆ In enclosed areas where there is smoke
  - ◆ During an overhaul until the air has been tested and deemed safe by the safety officer
  - ◆ Whenever toxic gases or an oxygen-deficient atmosphere is possible
- Golden rule: Always assume that the atmosphere is hazardous until it has been tested and proven to be safe!

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### Legal Requirements

- California Code of Regulations Title 8, Section 5144 (Cal/OSHA)



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- NIOSH
  - ◆ Sets the design, testing, and certification requirements for SCBA
- OSHA and state agencies
  - ◆ Are responsible for establishing and enforcing regulations for respiratory protection programs

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- NFPA standards related to SCBA:
  - ◆ NFPA 1500: basic requirements
  - ◆ NFPA 1404: requirements for SCBA training
  - ◆ NFPA 1981: requirements for design, performance, testing, and certification of open-circuit SCBA

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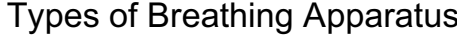
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- Open-circuit SCBA
  - ◆ Most common type of SCBA used for structural fire fighting



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### Open-Circuit



- Exhaled air is exhausted to the atmosphere
- ◆ Types:
  - ◆ Demand
  - ◆ Supplied air respirators
  - ◆ Positive pressure

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### Demand



- Air supply is delivered to mask by negative pressure created during inhalation
- Not legal for fire service use

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### Supplied Air Respirators

- Often called airline equipment
- Similar to SCBA
  - ◆ Air supply cylinder is remote from user
  - ◆ Hose connecting regulator to the cylinder may be up to 200 feet long



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### Supplied Air Respirators



- Often used with a small capacity air cylinder
  - ◆ Carried by user
  - ◆ For emergency escape purposes
- Can be a standard SCBA modified to be used with air supply hose

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### Supplied Air Respirators

- Hazardous materials incidents
- Confined space rescues
- Generally NOT used for fire fighting
  - ◆ Except for firefighters in aerial baskets



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### Positive pressure



- Used almost universally in the fire service.
- Slight positive pressure is maintained in the mask
  - ◆ Prevents contaminated air from entering the mask if the seal between the mask is broken.

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**Closed-Circuit**

- Exhaled air is recalculated in the system:
  - ◆ O<sub>2</sub> is added
  - ◆ CO<sub>2</sub> is removed
- Fire service requirements:
  - ◆ Must be rated for 30 minutes minimum
  - ◆ Must be positive pressure



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**Closed-Circuit**

- Compressed oxygen units:
  - ◆ Carry small supply of O<sub>2</sub>
  - ◆ CO<sub>2</sub> removed by scrubbers
- Chemical generator units:
  - ◆ O<sub>2</sub> is produced by a chemical process within the SCBA
  - ◆ Used by military and industry for specialized applications
  - ◆ Use by the fire service not recommended



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**Limitations of SCBA**

- Duration of work using SCBA limited by the capacity of the cylinder
  - ◆ SCBA for structural fire fighting must carry enough air for a minimum of 30 minutes .
  - ◆ Duration ratings based on ideal laboratory conditions.

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### Limitations of SCBA

- Generally, an SCBA weighs at least 25 pounds.
- Size of unit makes it difficult for user to fit into small places.
- Added weight and bulk decrease user's flexibility and mobility.



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### Limitations of SCBA

- Face piece can limit visibility, particularly peripheral vision.
- Face piece may fog up under some conditions.
- SCBA also may affect the user's ability to vocally communicate.
- SCBA is noisy during breathing, which may limit the user's hearing.

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### Components of SCBA

- Four Basic Components
  - ◆ Backpack assembly
  - ◆ Air cylinder
  - ◆ Regulator assembly
  - ◆ Face piece assembly



Note: Refer to manufacturer's manual

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## Backpack Assembly

- Holds unit in place on back
- Manufactured of metal and/or high temperature resistant materials, it should not burn
- Adjustable harness straps:
  - ◆ All straps should be secured
  - ◆ Adjust straps to carry most of the weight on the hips

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## Air Cylinder

- Air cylinder
  - ◆ Holds breathing air for an SCBA
  - ◆ Neck equipped with a hand-operated shut-off valve
  - ◆ Pressure gauge located near the shut-off valve and shows amount of pressure currently in cylinder



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## Air Cylinder

- Construction:
  - ◆ Steel (generally no longer in use)
  - ◆ Aluminum
  - ◆ Fiberglass wrapped
    - ◆ Aluminum liner shell
    - ◆ Hoop-wrapped
    - ◆ Full-wrapped



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### Air Cylinder

- Construction (cont):
  - ◆ Kevlar/carbon composite



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### Cylinder Capacities

- Cylinder pressure gauge
  - ◆ 4,500 psi
- High pressure
  - ◆ 4,500 psi
- Low pressure
  - ◆ 2,216 psi
  - ◆ 3,000 psi for carbon fiber cylinders

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### Cylinder Rated Duration



- 30 minutes
  - ◆ 45 cubic feet
- 45 minutes
  - ◆ 65 cubic feet
- 60 minutes
  - ◆ 88 cubic feet

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### Cylinder Service Life

- Hydrostatic test
  - ◆ Ensures cylinder is capable of withstanding filling to rated capacity
- Steel & Aluminum cylinders
  - ◆ Hydro test every 5 years
  - ◆ Unlimited service life
- Fiberglass/Kevlar wrapped & composite
  - ◆ Hydro test every 3 years
  - ◆ Max service life of 15 years



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### Regulator

- Controls the flow of air to the user
- Reduces cylinder pressure
- Two Stages
  - ◆ Second stage may be mounted on face piece



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### Regulator

- Bypass valve
- Low pressure warning device
  - ◆ Activated at 450-550 psi



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### Regulator Operation

- Inhaling
  - ◆ decreases the air pressure in the face piece, which opens the regulator and releases air from the cylinder into the face piece
- Exhaling
  - ◆ opens the exhalation valve, which exhausts used air into the atmosphere

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### Regulator Operation

- SCBA regulators will maintain a slightly positive air pressure in the face piece.
- Normal operational mode
  - ◆ Regulator supplies breathing air during inhalation, stops when inhalation stops, then opens an exhalation valve to exhaust used air into the atmosphere.
  - ◆ Controlled using the yellow-colored on/off valve

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### Regulator Operation

- Emergency by-pass mode:
  - ◆ Releases a constant flow of breathing air into the face piece
  - ◆ Used only if the regulator malfunctions
  - ◆ Activated when the user turns on the red-colored emergency by-pass valve



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**Face Piece Assembly**

- Face piece assembly consists of:
  - ◆ Facemask with a clear lens
  - ◆ Exhalation valve
  - ◆ Head Harness



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**Face Piece Assembly**

- Models with harness-mounted regulator face pieces have a flexible low-pressure hose.
- Later models will have the regulator attached directly to the face piece.
- Some have Nose Cups for Antifogging



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**Face Piece Assembly**

- Face piece should cover the entire face.
- Some models have a voice amplification device to improve communications:
  - ◆ Speaking diaphragms
  - ◆ Mask mounted amplifiers
  - ◆ Radio interfaces
- Face pieces are manufactured in several sizes.

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**Face Piece Accessories**


- Vision Aids
  - ◆ Avoid standard eyeglasses & contacts
- Air supply gauges/monitors in mask
- Buddy breathing hose connections
  - ◆ Emergency use only to connect to same type SCBA
- Emergency air fill connection

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**Pathway of Air through an SCBA**

- Air passes through the cylinder shut-off valve into the high-pressure hose that takes it to the regulator.
- Regulator reduces high pressure air to low pressure.
- Air next goes directly into the face piece.

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**Pathway of Air through an SCBA**

- From the face piece, the air is inhaled through the user's air passages and into the lungs.
- When the user exhales, used air is returned to the face piece.
- Exhaled air is exhausted from the face piece through the exhalation valve.

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### SCBA Components

- A self-contained breathing apparatus consists of four basic components: backpack assembly, air cylinder, regulator assembly, and face piece assembly. SCBA accessories will enhance the use of the basic components and assist the SCBA to function better. All of these components contribute to the proper operation of the SCBA. You must understand these functions in order to develop proficiency and confidence in the use of the SCBA.

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### Air Supply Duration

- NIOSH and the Mine Safety and Health Administration (MSHA) require the following manufacturer's statement
  - ◆ "The user should not expect to obtain exactly 30-minutes of service life from this apparatus for each use"



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### Air Supply Duration

- Averages
  - ◆ Low pressure cylinder
    - ◆ One minute per 100 psi
  - ◆ High pressure cylinder
    - ◆ One minute per 200 psi
- Duration could be cut in half depending on how strenuous the work



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### Factors Reducing Air Supply

- Improper maintenance
- Outdated equipment
- Deterioration or damage of components
- Misuse
  - ◆ Dropped or underwater
- Mechanical/chemical
  - ◆ Exposure to excessive heat, etc.
- Inadequate filling of cylinders

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### Physical Limitations of the User

- Moving with the extra weight of SCBA and PPE requires additional energy, which increases air consumption and body temperature.



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### Physical fitness of Firefighter

- Aerobic capacity
- Muscular endurance
- Muscular strength
- Flexibility



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### Psychological Limitations of the User

- Breathing through an SCBA is different from normal breathing and can be very stressful.
- The surrounding environment, which is often dark and filled with smoke is foreign as well.
- Firefighters must adjust to these stressful conditions.

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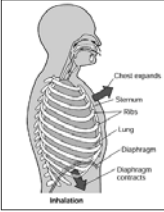
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### Skip-Breathing Technique

- Skip-breathing helps conserve air.
- Take a short breath, hold, take a second short breath (do not exhale in between breaths).
- Relax with a long exhale.
- Each breath should take 5 seconds.



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### Factors Affecting Air Supply

- Numerous factors affect the air supply duration of a self-contained breathing apparatus. These include equipment related, physical fitness of the firefighter, physiological considerations, and psychological responses. For many of these factors, the firefighter can take proactive steps to reduce the negative effects. In order to maximize their effectiveness on the fireground, firefighters should work to increase their air supply duration.

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### Mounting Breathing Apparatus



- SCBA should be located so that firefighters can don it quickly when they arrive at the scene of a fire.
- Exterior-mounted SCBA should be protected from weather and dirt by a secure cover.

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### Donning SCBA



- firefighters must be able to don and activate SCBA in one minute.
- firefighters must be wearing full PPE before donning SCBA.
- Check the SCBA to ensure it is ready for operation before donning it.

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### Pre-donning SCBA Check

- Check that air cylinder has at least 90% of its rated pressure.
- If the SCBA has a donning/doffing switch, be sure that it is activated.
- Open the cylinder valve two or three turns, listen for the low-air alarm to sound, and then open the valve fully.

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### Pre-donning SCBA Check

- Check that pressure gauges on both the regulator and cylinder read within 100 psi of each other.
- Check that all harness straps are fully extended.
- Check that all valves are in the correct position.
  - ◆ An open by-pass valve will waste air.

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### Safety Precautions for SCBA

- Learn to recognize the low-air alarm.
- As soon as your alarm goes off, you must exit the hazardous environment.
- Before you enter a hazardous environment, make sure your PASS device is activated.



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### Safety Precautions for SCBA

- Be sure you are properly logged into your accountability system.
- Always work in teams of two.
- Always have at least two firefighters outside at the ready.
- firefighters track working in IDLH environments

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### Preparing for Emergency Situations

- Be prepared to react if an emergency occurs while using SCBA.
- Keep calm, stop, and think.
- Exit the hostile environment.
- If in danger, activate your PASS.
- Use your hand light to attract attention.
- Use a portable radio to call for help.

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### Doffing SCBA

- Follow procedures recommended by the manufacturer and your department's SOPs.
- In general, you should reverse the steps for donning SCBA.



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### Putting It All Together



- Complete PPE ensemble consists of personal protective clothing and SCBA.
- You must be able to integrate donning PPE and SCBA.

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**SCBA Inspection and Maintenance**

- SCBA must be properly serviced and prepared for the next use each time it is used.
- Air cylinder must be changed or refilled.



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**SCBA Inspection and Maintenance**

- Face piece and regulator must be sanitized according to the manufacturer's instructions.
- Unit must be cleaned, inspected, and checked for proper operation.

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**SCBA Inspection and Maintenance**

- It is the user's responsibility to ensure that the SCBA is in ready condition before it is returned to the fire apparatus.
- The daily inspection procedure should be used when restoring a unit to service after it has been used.

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## SCBA Inspection and Maintenance

- If an SCBA inspection reveals any problems that cannot be remedied by routine maintenance, the SCBA must be removed from service for repair.
- Only properly trained and certified personnel are authorized to repair SCBA.

Ch.2

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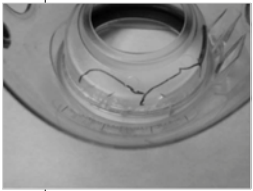
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## Daily Inspection



- Each SCBA unit should be inspected daily or at the beginning of each shift.
- When fire stations are not staffed, SCBA should be inspected at least once a week.

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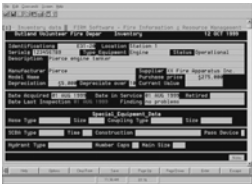
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## Monthly Inspection



- SCBA should be completely checked each month for proper operation, for leaks, and for any deterioration.

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**Annual Inspection**

- Complete annual inspection and maintenance must be performed on each SCBA.
- Annual inspection must be performed by a certified manufacturer's representative or a person who has been trained and certified to perform this work.

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**Servicing SCBA Cylinders**



- Cylinders must be visually inspected during daily and monthly inspections.
- Federal law requires periodic hydrostatic testing and limits the number of years a cylinder can be used.

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**Replacing SCBA Cylinders**

- A single firefighter must doff SCBA to replace the air cylinder.
- Two firefighters working together can change cylinders without removing SCBA.
- A firefighter should be able to change cylinders in the dark and while wearing gloves.

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### Refilling SCBA Cylinders

- Compressors and cascade systems are used to refill SCBA cylinders.
- Proper training is required to fill SCBA cylinders.



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### Refilling SCBA Cylinders



- Air utilities or breathing support units:
  - ◆ Cascade
  - ◆ Complete system
  - ◆ Vehicle
  - ◆ Trailer

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### Cleaning and Sanitizing SCBA

- Follow manufacturers' specific instructions for care and cleaning of SCBA.
- Rinse entire unit using a hose with clean water.
- Clean harness assembly and cylinder with a mild soap and water solution.

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**Cleaning and Sanitizing SCBA**

- Clean face pieces and regulators with mild soap and warm water or disinfectant cleaning solution.



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**Summary**

- The primary respiratory protection equipment used by the fire service is the open-circuit SCBA.
  - ◆ firefighters must know the limitations of SCBA, their own physical and psychological limitations.
  - ◆ firefighters should be able to don SCBA in one minute or less.

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**Summary**



- Regular inspection and proper maintenance of SCBA is vital to firefighter safety and is an important responsibility of every firefighter.

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