RESPIRATORY PROTECTION

1.0 INTRODUCTION

Respiratory protection is needed if personnel must enter any area in which there may be a deficiency of oxygen or an elevated concentration of airborne contaminants. The objective of this module is to provide basic information on the selection, use and maintenance of respiratory protective devices so they may be used in a safe and effective manner.

In the day-to-day field activities under EPA jurisdiction, Agency employees are confronted with a variety of atmospheric hazards. This module provides Agency personnel with the basic information needed to make intelligent decisions as to when, where and how to use respiratory protection devices.

Learning Objectives
At the end of this module, you will be able to:

- Recognize types of respiratory hazards
- Identify various types of respirators and the conditions under which they are used
- Describe the criteria used for respirator selection
- Explain proper respirator procedures (i.e., fit-testing, donning/doffing, maintenance)
- Explain the requirements and special considerations associated with respirator use.

2.0 RECOGNITION OF RESPIRATORY HAZARDS

Respiratory hazards may be encountered during any field activity. Respiratory protection is needed if personnel must enter any area in which there may be either a deficiency of oxygen or an elevated concentration of toxic chemicals in the air to cause adverse health effects. In such atmospheres, life or health may depend on using respiratory equipment which can provide a supply of clean breathing air.

Examples of locations where respiratory hazards commonly exist include:

- Spill scenes
- The vicinity of discharge or emission sites
- Mines
- Industrial plants
- Hazardous waste sites
- Confined spaces.

Respiratory hazards fall into three basic categories:

- Oxygen deficiency
- Aerosols

- Gases and vapors.

Within such categories, the hazard may be created by various factors such as the systemic toxicity of the material or its ability to cause irritation or discomfort.

2.1 Oxygen Deficiency

Oxygen deficiency can occur when air is displaced by gases and vapors heavier than air, or when the oxygen is removed by oxidation processes such as fire, rusting, or aerobic bacterial action. The effects of oxygen deficiency on a person can range from minor to fatal.

OSHA defines an oxygen-deficient atmosphere as air containing oxygen at a concentration below 19.5 percent at sea level. This minimum requirement provides an adequate amount of oxygen for most work assignments and includes a safety factor. The safety factor is needed because oxygen-deficient atmospheres offer little warning of the danger. Continuous measurement of an oxygen-deficient atmosphere may be necessary. Air purifying respirators cannot be used when oxygen concentrations are less than 19.5%; only supplied-air systems are appropriate.

2.2 Aerosols

Aerosol is a term used to describe fine particulates (solid or liquid) suspended in air. Aerosols can be classified in two ways: by their physical form and origin and by the physiological effect on the body.

2.2.1 Physical Classification

Mechanical dispersoids are liquid or solid particles suspended in air that are mechanically produced; condensation dispersoids refer to those particles produced by combustion.

- Dust: Visible solid mechanical dispersoid
- Spray: Visible liquid mechanical dispersoid
- Fume: Extremely small solid condensation dispersoid
- Mist: Liquid condensation dispersoid
- Fog: Mist which is dense enough to obscure vision
- Smoke: Liquid or solid organic particles resulting from incomplete combustion
- Smog: Mixture of smoke and fog.

2.2.2 Physiological Classification

Aerosols can have the following effects on the body:

- Nuisance: No lung injury but proper lung functioning inhibited
- Inert pulmonary reaction: Non-specific reaction

- Pulmonary fibrosis: Effects ranging from nodule production in lungs to serious diseases such as asbestosis
- Chemical irritation: Irritation, inflammation, or ulceration of lung tissue
- Systematic poison: Diseases in other parts of the body
- Allergy-producing: Causes allergic hypersensitivity reactions such as itching, sneezing, or asthma
- Carcinogen: Causes cancer of the lung or other parts of the body.

2.3 Vapor and Gaseous Contaminants

Gaseous contaminants can be classified chemically and physiologically.

2.3.1 Chemical Classification

- Acidic: Acids or chemicals that contain hydrogen, create a pH <7.0 and whose solutions have the following properties:
  - Corrosive
  - Sour taste
  - Ability to react with certain metals and bases/alkalines to form salts
- Alkaline: Bases or chemicals in which water solutions are bitter and irritating or corrosive to the skin, pH >7.0
- Organic: Compounds which contain carbon and may range from methane to chlorinated organic solvents
- Organometallic: Organic compounds containing metals
- Hydrides: Compound in which hydrogen is bonded to another metal
- Inert: No chemical reactivity.

2.3.2 Physiological Classification

- Irritants: Corrosive substances which injure and inflame tissue
- Asphyxiant: Substances which displace oxygen or prevent the use of oxygen in the body
- Anesthetics: Substances which depress the central nervous system, causing a loss of sensation or intoxication
- Systematic poisons: Substances which can cause disease in various organ systems
- Allergy-producing: Causing allergic hypersensitivity reactions such as itching, sneezing, or asthma
- Carcinogen: Causes cancer of the lung or other part of the body.

3.0 TYPES OF RESPIRATORS

The basic purpose of any respirator is to protect the respiratory system from inhalation of hazardous materials. Respirators provide protection in one of two ways:

- By removing contaminants before the air is inhaled (air purifying respirators)

- By supplying an independent source of breathable air (atmosphere-supplying respirators).

All respirators consist of two basic components:

- The facepiece
- The device that provides clean, respirable air.

3.1 Respirator Facepieces

The type of facepiece is one of the basic factors that determines the degree of protection provided by a respirator. There are tight-fitting and loose-fitting facepieces.

3.1.1 Tight-fitting

The three basic types of tight-fitting facepieces include:

- Quarter mask: Covers the mouth, nose, and the lower sealing surface rests between the chin and mouth; generally not recommended because it is easily dislodged. (Note: EPA does not sanction the use of quarter masks.)
- Half mask: Fits over the nose and under the chin.
- Full facepiece: Covers from the hairline to below the chin; usually seals most reliably and provides some eye protection.

The tight-fitting half mask and full facepiece are usually worn with respiratory protective devices used during field activities.

3.1.2 Loose Fitting

Loose-fitting facepieces include hoods, helmets, and suits and are only useable with respirators that maintain a positive pressure inside the facepiece. Consequently these loose-fitting units are used only with either air-supplied systems or powered air-purifying systems.

3.2 Air-Purifying Respirators

Air-purifying respirators consist of a facepiece and air-purifying device, which is either a removable component of the facepiece (cartridge type) or an air-purifying apparatus worn on a body harness and attached to the facepiece with a corrugated breathing hose (canister type).

Air-purifying respirators selectively remove specific airborne contaminants, such as particulates, gases, vapors, and fumes, from ambient air by filtration, absorption, adsorption, or chemical reaction. Therefore, the type of contaminants that can be removed by a particular respirator will depend on the type of removal medium present in the cartridges or canisters being used. For example, charcoal canisters will provide some protection against organic solvent vapors but not against acid gases.

Air-purifying respirators are approved only for use in atmospheres containing specific chemicals up to designated concentrations. The chemicals and concentrations for which a respirator is approved are written on the cartridges or canisters. The labelling requirements for these cartridges and canisters are specified in the OSHA standard (29 CFR 1910.134).

In addition, each canister is color coded according to the contaminant or contaminant class for which it is designated. Table 1 lists the OSHA required color coding for some commonly employed types of canisters.

TABLE 1: COLOR CODES FOR CANISTERS

Atmospheric contaminants to be protected against	**Colors assigned** [1]
Acid gases	White
Hydrocyanic acid gas	White with 1/2 inch green stripe completely around the canister near the bottom
Chlorine gas	White with 1/2 inch yellow stripe completely around the canister near the bottom
Organic vapors	Black
Ammonia gas	Green
Acid gases and ammonia gas	Green with 1/2 inch white stripe completely around the canister near the bottom
Carbon monoxide	Blue
Acid gases and organic vapors	Yellow
Hydrocyanic acid gas and chloropicrin vapor	Yellow with 1/2 inch blue stripe completely around the canister near the bottom
Acid gases, organic vapors, and ammonia gases	Brown
Radioactive materials, excepting tritium and noble gases	Purple (Magenta)
Particulates (dusts, fumes, mists, fogs, or smokes) in combination with any of the above gases or vapors	Canister color for contaminant, as designated above, with 1/2 inch gray stripe completely around the canister near the top
All of the above atmospheric contaminants	Red with 1/2 inch gray stripe completely around the canister near the top

[1] Gray shall be the main color for a canister designed to remove acids or vapors.

NOTE: Orange shall be used as a complete body, or stripe color to represent gases not included in this table. The user will need to refer to the canister label to determine the degree of protection the canister will afford.

Source: OSHA 29 CFR 1910.134

Because of the characteristics of air-purifying respirators, they should only be used when:

- The identity and concentration of the contaminant are known
- The oxygen content in air is at least 19.5 percent
- The contaminant has adequate warning properties
- Approved canisters or cartridges for the contaminant and concentration are available
- The Immediately Dangerous to Life or Health (IDLH) concentration is not exceeded.

If any of these criteria are not met, an air-purifying respirator may not provide adequate protection, and an atmosphere-supplying respirator should be used instead.

The following configurations are available for air-purifying respirators:

- Half-mask with twin cartridges
- Half-mask with powered air-purifying unit worn on the belt at the waist
- Full face mask with twin cartridges
- Full face mask with chin-mounted canister
- Full face mask with harness-mounted canister
- Full face mask with powered air-purifying unit worn around the waist.

3.3 Atmosphere-Supplying Respirators

Atmosphere-supplying respirators consist of a facepiece (either loose or tight-fitting) and a device to provide clean respirable air (minimum CGA Grade D). There are two basic types of atmosphere-supplying respirators: the self-contained breathing apparatus and the supplied air respirator.

The immediate source of air for air-supplied respirators, typically, is a mechanical compressor or a tank of compressed breathing air.

Oxygen must meet the requirements of the United States Pharmacopoeia for medical or breathing oxygen. Breathing air must meet at least the requirements of the specification for Grade D breathing air as described in the Compressed Gas Association Commodity Specification G7.1-136.6.

In cases where a mechanical compressor supplies the breathing air, the oil, water, and carbon monoxide must be removed from the air prior to use. Even when using a self-contained breathing apparatus (SCBA) or breathing air cylinder, air quality is a major concern. Users of these air cylinders should make sure the supplier is aware of the need for air purification. The facility should request certificates of analysis with every shipment of cylinders, and should use only air that meets breathing air" quality standards.

3.3.1 Self-Contained Breathing Apparatus (SCBA)

A self-contained breathing apparatus (SCBA) usually consists of a facepiece connected by a hose and a regulator to an air source (compressed air, compressed oxygen, or an oxygen-generating chemical) carried by the wearer.

Some characteristics of SCBAs are:

- They offer protection against most types and levels of airborne contaminants.
- The duration of their use is limited by the amount of air carried and the rate of consumption.
- They increase the likelihood of heat and physical stress and may impair movement in confined space because they are bulky and heavy.

There are two types of apparatus:

- Closed-circuit
- Open-circuit.

Closed-circuit SCBAs use compressed oxygen and open-circuit SCBAs use compressed air. The closed-circuit SCBA, commonly called the rebreather, recycles exhaled breath and carries only a small oxygen supply, resulting in a considerably greater service time than an open-circuit device. In an open-circuit device the exhaled air is exhausted from the system. The wearer must carry the full air supply.

SCBAs may operate in one of two modes:

- Demand
- Pressure-demand.

In the demand mode, a negative pressure is created inside the facepiece and breathing tube when the wearer inhales. This negative pressure draws down the admission valve, in the regulator, which allows air to be inhaled. As long as the negative pressure remains, air flows to the facepiece. The problem with demand operation is that the wearer can inhale contaminated air through any gaps in the facepiece-face sealing surface.

In the pressure-demand mode, a positive pressure is maintained inside the facepiece at all times. The system is designed so that the admission valve remains open until enough pressure is built up to close it. The pressure builds up because air is prevented from leaving the system until the wearer exhales. Any leakage is outward from the facepiece. It is EPA policy that the "pressure-demand" respirator is the only type of air supplied respirator authorized for use by EPA personnel.

3.3.2 Supplied-Air Respirators (SARs)

Supplied-air respirators (SARs), also known as air-line respirators, supply air, never oxygen, to a facepiece via a supply line from a stationary source. SARs are available in positive-pressure and negative-pressure modes. Pressure-demand SARs with escape provisions provide the highest level of protection among SARs and are the only SARs recommended for use at hazardous waste sites.

SARs are not recommended for entry into potentially immediately dangerous to life or health (IDLH) atmospheres unless the apparatus is equipped with an escape SCBA.

All SAR couplings must be incompatible with the outlets of other gas systems used on-site to prevent a worker from connecting to an inappropriate compressed gas source (OSHA 29 CFR 1910.134).

3.3.3 Combined SCBA/SARs

A relatively new type of respiratory protection is available that uses a regulator to combine the features of an SCBA with a SAR. The user can operate the respirator in the SCBA or SAR mode, through either the manual or automatic switching of air sources.

This type of respirator allows entry into and exit from an area using the self-contained air supply, as well as extended work periods within a contaminated area while connected to the air line. It is particularly appropriate for sites where workers must travel an extended distance to a work area within a hot zone and remain within that area for relatively long work periods. In such situations, workers would enter the site using the SCBA mode, connect to the air line during the work period, and shift back to the SCBA mode to leave the site.

3.4 Respirator Approval and Certification

Before selecting a respirator for use, check to ensure that it has been certified and approved by the National Institute for Occupational Safety and Health (NIOSH). Certification and approval are based on tests conducted by NIOSH.

All respirators and respirator components built to the same specifications will have an approval designation displayed on the respirator or its container. The designation will consist of the letters TC (for Testing and Certification) and two groups of numbers which indicate the type of equipment and the specific approval. The approval label will also include the name of the certification agency, NIOSH. Respirators and their components are certified as a unit. Interchanging parts from a different manufacturer will void the certification.

With air-purifying respirators it is important to note that the certification approves the air-purifying element only for certain materials and conditions of use. For example, air-purifying respirators approved for protection against organic vapors may only be used against organic vapors with adequate warning properties and in an atmosphere containing at least 19.5 percent oxygen. Limits are also placed on the concentration in which a given respirator may be used.

3.5 Respirator Performance Rating

NIOSH rates the performance of each type of respirator in terms of an assigned protection factor (APF). The APF is the ratio of the concentrations outside and inside the respirator facepiece, meaning the factor by which the outside concentration is reduced inside the respirator:

$$APF = \frac{\text{Outside Concentration}}{\text{Inside Concentration}}$$

For example, a respirator with an APF of 100 will reduce the outside concentration 100 times, so an outside concentration of 200 parts per million (ppm) would be reduced to 2 ppm inside the facepiece. The APF assumes that the facepiece is properly fitted to the user and that the purifying element is capable of removing the contaminant in question.

Given the APF for a respirator, and the allowable exposure limit (e.g., TLV, PEL, or REL) of the contaminant against which it will be used, it is possible to determine the maximum concentration in which a given respirator may be used by using the following formula:

Maximum Use Concentration (ppm) = APF x Allowable Exposure Limit

For example, an air-purifying half mask respirator has an APF of 10. For protection against a contaminant with an American Conference Governmental Industrial Hygiene (ACGIH) threshold limit valve (TLV) of 20 ppm, this respirator may be used in concentrations up to:

APF x TLV = 10 x 20 = 200 ppm

If higher concentrations are anticipated, a form of respiratory protection with a higher APF must be used. Under no circumstances, however, must the capacity of the respirator (stated on the side of the cartridge) be exceeded.

4.0 RESPIRATOR SELECTION

Respirator selection is a complex process that should be performed only by a trained industrial hygienist. In the event that an industrial hygienist is not available, respirator selection should be performed by an equally competent trained employee.

Specifically, selection of adequate respiratory protection for field activities should include:

- The nature of the hazardous operation, process or condition
- The contaminant(s), type of hazard, concentration, and effects on the body
- The activities to be conducted in the hazardous area
- The length of time that respiratory protection will be needed
- The time required to get out of the hazardous area to the nearest area having respirable air

- The specific characteristics of the respiratory protective devices that are available within the Agency or that can be purchased, including service life for cartridges and canisters.

In addition, the user must assemble the necessary toxicologic, safety, and other relevant information for each contaminant, including the following:

- Physical, chemical, and toxicologic properties of the contaminant(s)
- Odor threshold data
- NIOSH-recommended exposure limit (REL), or ACGIH threshold limit value (TLV), or, when no REL or TLV exists, OSHA-permissible exposure limit (PEL) or other applicable exposure limit
- Immediately dangerous to life or health (IDLH) concentration
- Eye irritation potential
- Any service life information available (for cartridges and canisters).

Given all of the above information, it is possible to select the appropriate respirator for a particular hazardous situation.

For the purpose of respirator selection, respiratory hazards can be placed in three general categories: oxygen deficiency, flammable atmospheres, and toxic atmospheres.

4.1 Oxygen Deficiency

The choice of respirators is very limited if the working atmosphere is potentially oxygen deficient. If an oxygen deficiency exists or is possible, the choice of adequate respiratory protection is limited to:

- Pressure-demand SCBA
- Air-line respirator with an auxiliary self-contained air supply.

Since oxygen deficiency presents an IDLH environment, efforts should be made to ventilate the space prior to entry.

4.2 Flammable Gas, Liquid, or Dust

It is EPA policy to measure flammable concentrations of gases and vapors before entering an area where such material may be present in hazardous amounts, and not to enter any area which has in excess of 25 percent of the lower explosive limit of material present. Such an environment should be considered IDLH. Nevertheless, unexpected spills or leaks may make entry of such hazardous areas necessary for rescue or other emergency reasons. Ensure that any equipment brought into this atmosphere is approved for use in hazardous locations (e.g., Class I, Division I rating).

If it is ever necessary to approach or enter areas in which flammable vapors or gases are present or possible in high concentrations, the respiratory protection must be a pressure-demand SCBA.

4.3 Toxic Contaminant Exposures

Exposure to toxic contaminants can be divided into three broad categories, depending on the degree of hazard. These three degrees of hazard are related to the concentrations of toxic materials present.

4.3.1 Concentrations Immediately Dangerous to Life or Health (IDLH)

NIOSH has defined IDLH as a concentration immediately dangerous to life or health which represents the maximum concentration from which, in the event of respirator failure, one could escape within 30 minutes without a respirator and without experiencing any escape-impairing (e.g., severe eye irritation) or irreversible health effects.

If an atmosphere is or may become "immediately dangerous to life or health," the choice of adequate respiratory protection is limited to pressure-demand SCBA.

4.3.2 Concentrations Above Permissible Exposure Limits but Below IDLH Level

Approved respiratory protection is required for exposures to toxic chemicals in airborne concentrations which are above the OSHA Permissible Exposure Limits (PELs) or other appropriate exposure limits (e.g., TLVs, RELs). Respiratory protection is also required for exposure to toxic substances in concentrations which may be expected to cause chronic toxic effects after repeated exposure, or acute adverse physiological symptoms after prolonged exposure.

4.3.3 Concentrations Below Permissible Exposure Limits (and Below IDLH)

When concentrations of toxic substances are below the Permissible Exposure Limits (PELs) or judged to be at concentrations below such limits, respiratory protection is not required. However, respiratory protection may be worn at the discretion of the individual. If the potential exists for concentrations to approach PELs or above, periodic monitoring should be conducted to ensure levels remain below established PELs. Consideration of the data establishing concentrations below the PEL alone may not be sufficient to eliminate the use of respiratory protection. The potential for rapid changes in concentrations must also be considered before working while unprotected. If this situation is encountered, it is fitting and proper that the respiratory protection remain donned.

5.0 RESPIRATOR USE

There are many requirements which must be fulfilled before respirators are used, in order to ensure the safe and effective performance of respiratory protection.

5.1 EPA Policy and Requirements

It is EPA policy to provide appropriate respiratory protection devices for EPA employees and to require use of such protective devices whenever they are necessary to protect employee health. Employees are entitled to wear respiratory protection if they are irritated by any material, even though the concentrations of material may not be expected to cause any adverse health effects, and even though the concentrations do not seem to affect others nearby in a similar way.

EPA policy requires use of respiratory protection in four situations:

- When there is a high potential for a sudden release of toxic gases or vapors or there has been such a release
- When preparing to enter hazardous environments or locations, such as waste or spill sites, where it is known or there is a reasonable belief that toxic airborne contaminants are present
- When preparing to enter confined spaces, such as manholes and unventilated buildings where there may be an oxygen deficiency (Note: confined space entry training must also be completed)
- During infrequent but routine operations where it is not feasible to limit concentrations of toxic material to safe levels by engineering controls.

The following issues are also addressed in the EPA's respiratory protection policy:

- Responsibilities
- Selection
- Training
- Inspection, Maintenance, Storage, and Repair
- Medical Monitoring
- Limitations
- Special Considerations.

Consult EPA Order 1440.3 for additional details.

5.2 OSHA Respirator Program Requirements

When respirators are used, whether required or not, the OSHA regulations governing respiratory protection must be implemented. These regulations are found in 29 CFR 1910.134 and are summarized below:

- Physical Examinations: Workers should not be assigned to tasks requiring the use of respirators unless it has been first determined that they are physically able to perform the work and use the equipment. The local physician shall determine any pertinent health and physical conditions by performing an evaluation, including:

- Medical history, with special emphasis on cardiovascular or pulmonary disease
- Facial abnormalities that may interfere with a respirator seal
- Visual acuity
- Hearing ability
- Integrity of tympanic membranes
- Cardiovascular fitness
- Pulmonary function test
- Other tests deemed appropriate by the physician (e.g., endocrine evaluation, psychological status, neurological health, exercise stress tests).

• Written Program: Written standard operating procedures governing the selection and use of respirators shall be established. These procedures must be tailored to each working group for all field activities requiring respirator use.

• Respirator Selection: Respirators shall be selected on the basis of hazards to which the worker is exposed.

• Training: Users shall be instructed and trained in the proper use and limitations of the respirators they will use.

• Respirator Assignment: Where practical, the respirators should be assigned to individual workers for their exclusive use. This is particularly important for air-purifying respirators, which operate under negative pressure and, consequently, are highly dependent on a secure face seal for adequate protection. EPA personnel should provide their own respirators and not use site respirators, unless prior arrangements (e.g., fit test and approval) have been made.

• Cleaning: Respirators shall be cleaned and disinfected regularly. Those issued for the exclusive use of one worker should be cleaned after each day's use, or more often if necessary. Those used by more than one worker shall be cleaned and disinfected thoroughly after each use.

  In general, the cleaning procedure involves the following steps: disassemble the respirator (without using tools), wash the facepiece and breathing hoses in cleaner and sanitizer solution mixed in warm water (from 120 to 140 degrees Fahrenheit), rinse completely, and dry in a clean area.

• Storage: Respirators should be stored in a convenient, clean, and sanitary location or in a container that will keep them clean. If they are packaged in tight plastic bags and transported on field trips, it is important to protect the bag from being scratched or punctured and to ensure respirators are not stored improperly, causing the elastomer to get in an abnormal position. The respirators should also be protected against temperature extremes, excessive moisture, and prolonged exposure to direct sunlight.

- Inspection and Maintenance: Respirators used routinely shall be inspected during cleaning. Inspections shall include: tightness of connections and the condition of the face piece, head bands, valves, connecting tube and canisters, rubber and elastomer parts for pliability and signs of deterioration. Worn or deteriorated parts shall be replaced with certified parts supplied by the manufacturer for the product being repaired. Replacement of other than disposable parts and any repair must be done only by authorized, trained personnel. Respirators for emergency use, such as self-contained devices, are required to be thoroughly inspected at least once a month and after each use.

- Surveillance: Appropriate surveillance of work area conditions and the degree of employee exposure or stress shall be maintained. This means air monitoring must be performed to determine the concentration of contaminant in air.

- Program Evaluation: Continued effectiveness of the respiratory protection program within each region or office must be assured by review and evaluation of the written procedures and the activities by field personnel within the organization unit.

- Only NIOSH certified equipment shall be used.

- Fit testing: Users must receive fitting instructions, including demonstrations and practice in how the respirator should be worn, how to adjust it, and how to determine if it fits properly.

6.0 SPECIAL CONSIDERATIONS FOR RESPIRATOR USE

When respirator use is required, the following special factors must be considered:

- Facial hair
- Eye glasses
- Contact lenses
- Restricted vision from fogging
- Facial deformities
- Communication.

6.1 Facial Hair

Facial hair that lies along the sealing area of the tight-fitting, face-piece type respirator, such as beards, sideburns, mustaches, or even a few days growth of stubble, shall not be permitted on employees who are required to wear respirators that rely on a tight facepiece fit to achieve maximum protection. Facial hair between the wearer's skin and the sealing surfaces of the respirator will prevent a good seal and may allow leakage. In the case of positive pressure devices, facial hair will either reduce service time or waste breathing air. A worker should not enter a contaminated work area when conditions prevent a good seal of the respirator facepiece to the face.

6.2 Eye Glasses

Ordinary eye glasses cannot be used with full facepiece respirators since temple bars or straps that pass between the sealing surface of a full facepiece and the worker's face will prevent a good seal. Special corrective lenses can be mounted inside a full facepiece respirator and are available from all manufacturers of full facepiece respirators.

Eye glasses or goggles may interfere with the half facepieces. When interference occurs, a full facepiece with special corrective lenses should be provided and worn.

6.3 Contact Lenses

Several factors prohibit the use of contact lenses when any type of respiratory device is worn. This is especially true of atmosphere-supplying respirators. With full facepieces, incoming air directed toward the eye can cause discomfort from dryness, dirt, lint, or other debris lodging between the contact lens and the pupil. A tight fitting facepiece, if bumped, could dislodge a contact lens. Gas permeable lenses may absorb chemicals from the air and place them in direct contact with the cornea.

6.4 Restricted Vision from Fogging

Fogging may occur in the respirator mask and result in obstructed vision. To avoid this problem, anti-fog products can be used before donning the mask or nose cups can be installed in full-face respirators.

6.5 Facial Deformities

Facial deformities, such as scars, deep skin creases, prominent cheekbones, severe acne, and the lack of teeth or dentures, can prevent a respirator from sealing properly.

6.6 Communication

Talking while wearing a respirator equipped with a facepiece may break the seal of the facepiece. When communication is necessary within a contaminated area, it should be done with the help of special communicating equipment obtained from the manufacturer of the respirator. A good practice is using emergency hand signals agreed upon before beginning work.

7.0 RESPIRATOR TRAINING REQUIREMENTS

EPA standards require a minimum of six hours of initial training for users of respirators and two to four additional hours annually after the initial training. Records of training and fit testing of employees are to be maintained by the supervisor.

Safe use of respiratory protection equipment depends on thorough training. Every employee who may use a respirator needs to know when it is needed, which type is needed, what the capabilities and the limitations of the equipment are for specific exposures, and how to inspect and maintain the equipment.

Every user of respiratory protection equipment needs to learn how to put the equipment on, how to adjust it for a comfortable fit, and how to test the seal between the facepiece and the face to see that the equipment fits tightly enough to provide needed protection. In addition, every user needs to have the opportunity to wear the equipment in normal air for a period of familiarization and then to wear the equipment in a test atmosphere.

8.0 RESPIRATOR FIT TESTING AND USER SEAL CHECKING

All the care that goes into the design, manufacture and certification of a respirator to ensure its maximum efficiency will not protect the wearer if there is an improper match between facepiece and wearer or there are improper wearing practices. The problem is twofold. Assuming that more than one brand of a particular type of facepiece is available, the first problem is to determine which fits best. The second problem is to ensure that the user knows when the respirator fits properly.

Half masks and full facepieces have inherently different fitting characteristics. Moreover, several brands of each are marketed, each having slightly different fitting characteristics. Although every manufacturer designs facepieces to fit as broad a section of the working population as possible, no respirator marketed will fit everyone. Therefore, more than one brand of a given type of respirator should be purchased to take advantage of the different fitting characteristics of each. In this way, the chances of properly fitting all workers are increased. Having more than one facepiece to choose from also gives the worker a better chance of finding a respirator that is reasonably comfortable while providing good protection. It is in this process of matching the respirator to the individual user that the fitting test, particularly the quantitative test, has the greatest impact.

8.1 Fit Testing

For personnel required to wear a negative-pressure respirator, a fit test is essential to determine which respirator best conforms to the contours of the user’s face. A fit test is a rigorous protocol in which the tester challenges the face-to-face piece seal with a chemical agent (e.g., irritant smoke, isoamyl acetate). Detection of the chemical agent inside the face piece indicates the presence of a leak.

Personnel must receive a fit test prior to initial assignment to any task requiring the use of a respirator. Fit testing is necessary for new mask configurations, or if one's facial contours change radically from weight loss, injury, or illness.

Determination of facepiece fit ideally should involve both qualitative and quantitative tests. A qualitative test relies on the wearer's subjective response. A quantitative test uses equipment as a means of detecting facepiece leakage. The general advantages and disadvantages of each are as follows:

- Qualitative Tests:
    - Advantages: Usually, qualitative tests are fast, require no complicated, expensive equipment, and are easily performed in the field.
    - Disadvantages: Since most qualitative tests rely on the wearer's subjective response, they may not be entirely reliable.

- Quantitative Tests:
    - Advantages: The greatest advantage of a quantitative test is that it does not rely on a subjective response. The quantitative test is recommended when facepiece leakage must be minimized for work in highly toxic atmospheres or those immediately dangerous to life or health.
    - Disadvantages: Quantitative fitting tests require equipment that can be operated only by highly trained personnel. Each test respirator must be equipped with a sampling probe to allow removal of a continuous air sample from the facepiece, so that same facepiece cannot be worn in actual service.

Ideally, both qualitative and quantitative tests should be used. A quantitative test can be used in selecting the best respirator for each worker during training. To supplement the periodic quantitative fitting, a qualitative test can be used before each entry into a contaminated atmosphere.

The EPA has a Respiratory Protection Program Guide, Chapter 8, page 20, which establishes fit-test guidelines. These guidelines should be used for fit testing employees when: new respiratory protection is issued, annually as a part of a respiratory clearance process, and whenever significant facial alterations occur which may compromise the respirator's facial fit.

8.2 User Seal Checking

Once a respirator is selected, OSHA regulations require the user to perform negative and positive pressure tests each time the respirator is put on to check that the facepiece is properly positioned. When performing these tests, it is important not to displace the facepiece while blocking the valves.

9.0 SUMMARY

Respiratory protection may be necessary to protect workers from oxygen-deficient atmospheres and/or airborne contaminants.

Key concepts presented in this module are:

- Respiratory protection is needed if personnel must enter any area in which there may be either a deficiency of oxygen or an elevated concentration of toxic chemicals in the air.

- Respiratory hazards fall into three basic categories:
  - Oxygen deficiency
  - Aerosols
  - Gases and vapors.

- Air purifying respirators cannot be used when oxygen concentrations are less than 19.5%; only supplied-air systems are appropriate.

- Respirators provide protection in one of two ways:
  - By removing contaminants before the air is inhaled (air purifying respirators)
  - By supplying an independent source of breathable air (air-supplied respirators or SCBAs).

- NIOSH rates the performance of each type of respirator in terms of an assigned protection factor (APF). Using the APF and the allowable exposure limit of the contaminant it is possible to determine the maximum concentration in which a given respirator may be used.

- A respiratory protection program must include:
  - A written standard operating procedures governing the selection and use of respirators
  - Respirator selection based on hazards
  - Instruction and training in the proper use and limitations of respirators including respirator fit testing and fit checking
  - Determination of physical ability to perform work and use a respirator
  - Proper cleaning, maintenance, and storage of respirators
  - Routine inspection of respirators
  - Evaluation of the program to determine its effectiveness.

Measures you can take to ensure respiratory protection include:

- Use respirator types which have been evaluated and selected for the exposure at hand. Ensure that respirators are NIOSH approved.
- Do not use air purifying respirators when oxygen concentrations are less than 19.5%.

- Ensure that you have been medically evaluated, trained, and fit tested for the use of assigned respirators.
- Perform fit checks prior to each use. Ensure that facial hair, eye glasses, or facial deformities do not affect the seal between the facepiece and wearer.
- Store respirators so that they are protected from dust, direct sunlight, moisture, chemicals, deformations of face-piece and extreme temperatures.
- Clean and sanitize respirators after each day's use.

EXERCISE

Read the following questions and circle the correct answer or fill in the appropriate response.

1. An oxygen-deficient atmosphere is defined as an environment containing oxygen at a concentration below _______ percent at sea level.

2. The type(s) of respirator(s) worn in oxygen deficient atmospheres:

   a. SCBA
   b. Air-purifying respirator
   c. Supplied-air respirator (SARs)
   d. Both a and c

3. Examples of tight-fitting facepieces include:

   a. Full facepiece
   b. Helmet
   c. Half mask
   d. Hoods
   e. a and c
   f. b and d

4. List 3 of the 5 criteria which must be met in order for air-purifying respirators to be used:

   ____
   ____
   ____

5. SCBAs have the following characteristics:

   a. Offer protection against most contaminants
   b. Duration of use depends on the amount of air carried
   c. Should not be used in IDLH atmospheres
   d. a and b
   e. b and c
   f. All of the above

6. Respirator components are uniformly designed so that desired parts may be interchanged to provide the most appropriate level of protection for the user.

   a. True
   b. True, only if each component is individually certified
   c. False

7. In an environment containing approximately 250 ppm of acetic acid (PEL=10 ppm), which assigned protection factor (APF) would provide the most appropriate level of protection?

   a. APF of 10
   c. APF of 250

b. APF of 25 d. APF of 50

8. Respirator selection is a relatively simple process which is dependent on the type of contaminant present, the length of time protection will be needed, and the established exposure limits of the specific contaminant.

a. True b. False

9. Air monitoring indicates ammonia to be present at 50 ppm; oxygen at 20.1%. The PEL for ammonia is 25 ppm. Determine the type(s) of respirator(s) which may be appropriate for this environment, including rationale, APF, and cartridge type, if applicable.

10. Each time a respirator is worn, the user must perform:

a. Qualitative fit-tests
b. Quantitative fit-test
c. Positive and negative pressure checks
d. All of the above

EXERCISE KEY

Read the following questions and circle the correct answer or fill in the appropriate response.

1. An oxygen-deficient atmosphere is defined as an environment containing oxygen at a concentration below ***19.5*** percent at sea level.

2. The type(s) of respirator(s) worn in oxygen deficient atmospheres:

   a. SCBA
   b. Air-purifying respirator
   c. Supplied-air respirator (SARs)
   d. Both a and c

3. Examples of tight-fitting facepieces include:

   a. Full facepiece
   b. Helmet
   c. Half mask
   d. Hoods
   e. a and c
   f. b and d

4. List 3 of the 5 criteria which must be met in order for air-purifying respirators to be used:

   The identity and concentration of the contaminant are known
   The oxygen content in air is at least 19.5%
   The contaminant has adequate warning properties
   Approved canisters/cartridges for contaminant and concentration are available
   The IDLH concentration is not exceeded.

5. SCBAs have the following characteristics:

   a. Offer protection against most contaminants
   b. Duration of use depends on the amount of air carried
   c. Should not be used in IDLH atmospheres
   d. a and b
   e. b and c
   f. All of the above

6. Respirator components are uniformly designed so that desired parts may be interchanged to provide the most appropriate level of protection for the user.

   a. True
   b. True, only if each component is individually certified
   c. False

7. In an environment containing approximately 250 ppm of acetic acid (PEL=10 ppm), which assigned protection factor (APF) would provide the most appropriate level of protection?

   a. APF of 10
   b. APF of 25
   c. APF of 250
   d. APF of 50

8. Respirator selection is a relatively simple process which is dependent on the type of contaminant present, the length of time protection will be needed, and the established exposure limits of the specific contaminant.

   a. True
   b. False

9. Air monitoring indicates ammonia to be present at 50 ppm; oxygen at 20.1%. The PEL for ammonia is 25 ppm. Determine the type(s) of respirator(s) which may be appropriate for this environment, including rationale, APF, and cartridge type, if applicable.

   Air-purifying respirator
   APF: 5 or 10
   Cartridge: Ammonia and amines (green cartridge)
   Rationale: Enough oxygen (i.e., >19.5%) present to use APR and ammonia concentration is low enough. Therefore APR is sufficient.

10. Each time a respirator is worn, the user must perform:

    a. Qualitative fit-tests
    b. Quantitative fit-test
    c. Positive and negative pressure checks
    d. All of the above