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.

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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.

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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 or 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.

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Examples of Respiratory Hazards

- 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.

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Categories of Respiratory Hazards

- Respiratory hazards fall into three basic categories:
  - Oxygen deficiency
  - Aerosols/particulates
  - Gasses 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.

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Oxygen Deficiency

- Oxygen deficiency can occur when:
  - Air is displaced, for example, by gases and vapors heavier than air
  - 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.

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Oxygen Deficiency Defined

- 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.

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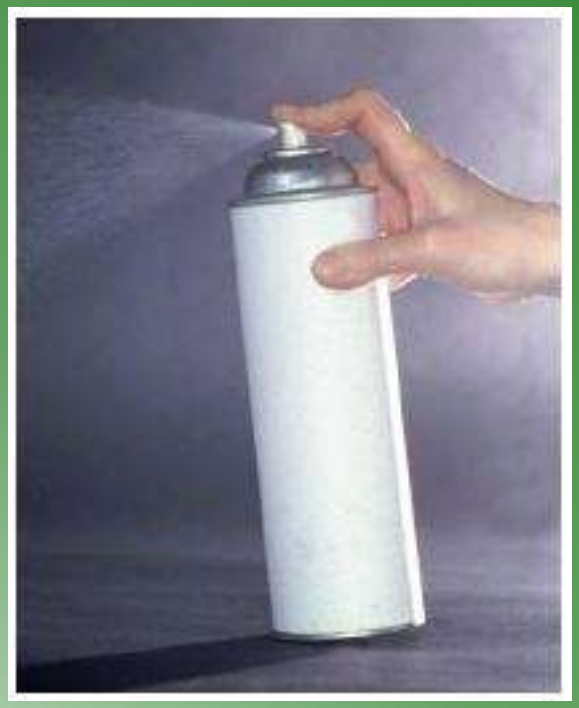
Aerosols



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

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Aerosols: Physical Classification

- Dust
- Spray
- Fume
- Mist
- Fog
- Smoke
- Smog

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Aerosols: Physiological Classification

- Nuisance
- Inert pulmonary reaction
- Pulmonary fibrosis
- Chemical irritation
- Systemic poison
- Allergy-producing
- Carcinogen

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Vapor and Gaseous Contaminants

- Vapor and gaseous contaminants are considered the third category of respiratory hazards.
- Gaseous contaminants can be classified chemically and physiologically.

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Vapor and Gaseous Contaminants: Chemical Classification

- Acidic acids 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
- Organomtetallic organic compounds containing metals
- Hydrides compound in which hydrogen is bonded to another metal
- Inert no chemical reactivity

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Vapor and Gaseous Contaminants: Physiological Classification

- Irritants
- Asphyxiant
- Anesthetics
- Systemic poison
- Allergy-producing
- Carcinogen

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Test your knowledge

- Respiratory hazards fall into three categories: oxygen deficiency, mutagens, and gases and vapors.
  - True
  - False

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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).

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Respirator Face Pieces

- All respirators consist of two basic components:
  - The face piece
  - The device that provides clean respirable air.
- The type of face piece is one of the basic factors that determines the degree of protection provided by a respirator. There are tight-fitting and loose-fitting face pieces.

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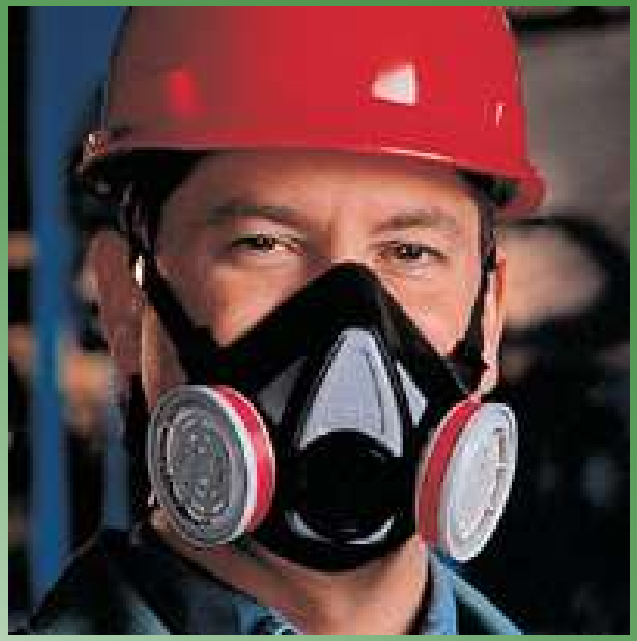
Air-Purifying Respirators



- Air-purifying respirators consist of a face piece and an air – purifying device, which is either a removable component of the face piece (cartridge type) or an air-purifying apparatus worn on a body harness and attached to the face piece 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 depends on the type of removal medium present in the cartridges or canisters being used. For example, charcoal canisters provide some protection against organic solvent vapors but not against acid gases.

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Air-Purifying Respirators: Approved Usage

- Air-purifying respirators are only approved 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 labeling requirements for these cartridges and canisters are specified in the OSHA standard (29CFR 1910.134)
- Each canister is color coded according to the contaminant or contaminant class for which it is designated.

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Air-Purifying Respirators: When to Use

- 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 the air is at lease 19.5 percent
  - The containment 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.

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Air-Purifying Respirators: Configurations

- 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.

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Atmosphere-Supplying Respirators

- Atmosphere-supplying respirators consist of a face piece (either loose or tight-fitting) and a device to provide clean respirable air (minimum Compressed Gas Association [CGA] Grade D).
- 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 lease the requirements of the specification for Grade D breathing air as described in the Compressed Gas Association Commodity Specification G7.1-1989.

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Atmosphere-Supplying Respirators: Air Purification

- 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. Even small amounts of oil contamination in an SCBA system can be fatal if it is dispersed into the lung.
- In cases where a mechanical compressor supplies the breathing air, the oil, water, and carbon monoxide must be removed from the air to a level to meet “breathing air” quality standards prior to use. Even when using a self-contained breathing apparatus (SCBA) or breathing air cylinder, air quality is a major concern.

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Self-Contained Breathing Apparatus (SCBA)

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

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Self-Contained Breathing Apparatus (SCBA): Types

- There are two types of self-contained breathing apparatuses:
  - Closed-circuit
  - Closed –circuit SCBAs use compressed oxygen and open-circuit SCBAs use compressed air. The close-circuit SCBA, commonly called the rebreather, recycles exhaled breath and carries only a small oxygen supply, resulting in a considerable greater service time than an open-circuit device.
  - Open-circuit
  - In an open-circuit device the exhaled air is exhausted from the system. The wearer must carry the air supply.

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Self-Contained Breathing Apparatus (SCBA): Characteristics

- Some characteristics of SCBAs are:
  - They protect 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.

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Self-Contained Breathing Apparatus (SCBA): Modes

- **Demand**- negative pressure from inhaling opens the valve to let the supplied air in.

- **Pressure-Demand**- constant low pressure at all times to pressurize the facepiece, then negative pressure from inhaling opens the valve fully.

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Supplied-Air Respirators (SARs)

- Supplied-air respirators (SARs) (also known as air-line respirators) supply air-line respirators) supply air, never oxygen, to a face piece 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 potential “immediately dangerous to life or health” (IDLH) atmospheres (MSHA/NIOSH 30 FCR Part 11) unless the apparatus is equipped with an escape SCBA.

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Combined SCBA/SARs

- A relatively new type of respiratory protection is available that uses a regulator to combine the features of an SCBA with an 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 are 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.

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Respirator Selection

- 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) and the Mine Safety and Health Administration (MSHA). Certification and approval are based on tests conducted by NIOSH.

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Respirator Approval and Certification

- All respirators and respirator components built to the same specifications have an approval designation displayed on the respirator or its container. The designation consists 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 also includes the names of the certification agencies, NIOSH and MSHA. Respirators and their components are certified as a unit. Interchanging parts from a different manufacturer voids the certification.

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Respirator Approval and Certification Restrictions

- 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 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.

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Respirator Performance Rating: APF

- 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 face piece, meaning the factor by which the outside concentration is reduced inside the respirator.

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Respirator Performance Rating

- 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 applying 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:
  - 200 ppm = 10 (APF) x 20 ppm (TLV)
- 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.

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Test your knowledge

- The three types of tight-fitting face pieces include full face piece, half mask, and _____

  - Helmet
  - Full mask
  - Quarter mask
  - Hood

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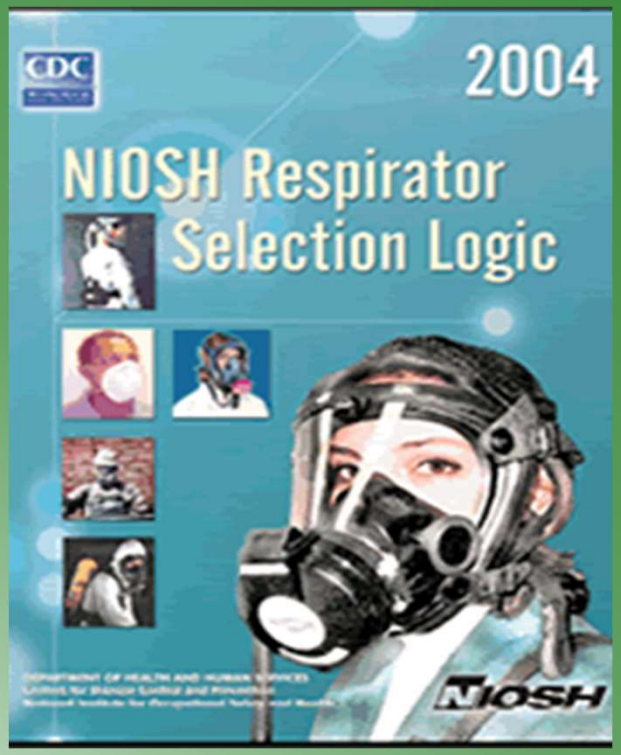
Respirator Selection



- 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 postponed, if possible, or performed by a competent employee with advanced training in respiratory protection.

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Respirator Selection: Consideration

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

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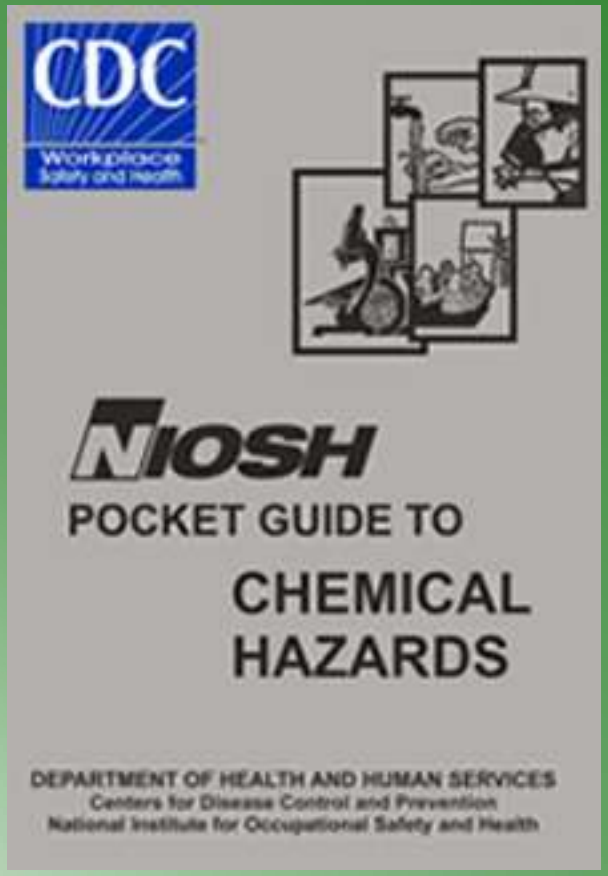
Respirator Selection: Contaminant Information



- 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)

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Respirator Selection: Respiratory Hazards

- For the purpose of respirator selection, respiratory hazards can be placed in three general categories:
  - Oxygen deficiency
  - Flammable atmospheres
  - Toxic atmospheres.

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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 and IDLH environment, efforts should be made to ventilate the space prior to entry.

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Flammable Gas, Liquid, or Dust

- Employers should measure flammable concentrations of gases and vapors before allowing entry to an area where such material may be present in hazardous amounts, and should not allow entry to 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 suck 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.

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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.
  - Concentrations Immediately Dangerous to Life or Health (IDLH)
  - Concentrations Above Permissible Exposure Limits but Below IDLH Level
  - Concentrations Below Permissible Exposure Limits (and Below IDLH)

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Test your knowledge

- The types of respirators worn in oxygen-deficient atmospheres are self-contained breathing apparatus (SCBAs) and air-purifying respirators.

  - True
  - False

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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.

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Policy and Requirements

- Employers should provide appropriate respiratory protection devices for employees and 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 no seem to affect others nearby in a similar way.

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Use of Respiratory Protection

- Respiratory protection should be used in the following 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.

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Respiratory Protection Policy

- Your employee handbook on respiratory protection policy should include the following:
  - Responsibilities
  - Selection
  - Training
  - Inspection, Maintenance, Storage, and Repair
  - Medical Monitoring
  - Limitations
  - Special Considerations

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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
- Physical Examination
- Written Program
- Respirator Selection
- Training
- Respirator Assignment
- Cleaning
- Storage
- Inspection and Maintenance
- Surveillance
- Program Evaluation
- NIOSH/MSHA
- Fit Testing

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Test your knowledge

- When respirators are used, whether required or not, the OSHA regulations governing respiratory protection must be implemented.

  - True

  - False

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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: Fogging
  - Communication
  - Facial Deformities

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Test your knowledge

- When and employee is required to wear a respirator that relies on a tight face piece to achieve maximum protection, the employee is allowed to have a mustache, but not a beard or sideburns.

  - True

  - False

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Respirator Training Requirements

- According to 29 CFR 1910.134(b)(3), the used must "be instructed and trained in proper use of respirators and their limitations," and 1910.134 (e)(5) requires that "the user be properly instructed in its selection, use, and maintenance," the content of the training can vary depending on the circumstances (e.g. types of equipment used, situations requiring respiratory protection) OSHA standards require training of both workers and supervisors which includes:
  - An opportunity to handle the respirator
  - Proper fitting of the respirator, with each wearer receiving 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.

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Respirator Training Requirements: Equipments Use

- Safe use of respiratory protections 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
  - How to inspect and maintain the equipment.

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Respirator Training Requirements: Wearing the Equipment

- Every user of respiratory protection equipment need to learn:
  - How to put the equipment on
  - How to adjust it for a comfortable fit
  - How to test the seal between the face piece an 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.

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Respirator Fit Testing and Fit 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 face piece and wearer or there are improper wearing practices.
- The problem is twofold. Assuming that more than one brand of a particular type of face piece 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.

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Respirator Fit Testing and Fit Checking

- Half masks and full face pieces have inherently different fitting characteristics. Moreover, several brands of each are marketed, each having slightly different fitting characteristics. Although every manufacture designs face pieces 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 face piece to choose from also gives the worker a better chance of finding a respirator that is reasonable 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.

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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., isoamyl acetate). Detection of the chemical agent inside the face piece indicates the presence of a leak. Testing with irritant smoke is no longer acceptable by OSHA if performed in an enclosed area.
- 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.

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Fit Testing: Type of Tests

- Determination of face piece fit ideally should involve both qualitative and quantitative tests. A qualitative test relies on the wearers subjective response. A quantitative test uses equipment as a means of detecting face piece leakage.
- 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.

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Fit Test Guidelines

- Fit-test guidelines should be used for fit testing employees (ask your supervisor). These guidelines identify when such testing should take place.
  - When new respiratory protection is issued
  - Annually as a part of a respiratory clearance process
  - Whenever significant facial alterations occur which may compromise the respirator's facial lift.

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Respiratory Protection Program Guidelines: EPA Example

- **Fitting**

- The proper fitting of respiratory protective devices requires the use of some type of fit test. The fit test is needed to determine a proper match between the face piece and the respirator and the face of the user.

- **Test atmospheres**

- It is required that the used be allowed to test the face piece to face seal of the respirator and wear it in a test atmosphere. The test atmosphere is an enclosure in which a test atmosphere (of low toxicity) can be generated and that the user can enter wearing the equipment.

- **Test Methods**

- Elaborate enclosures are available commercially, but a do it yourself qualitative fit test enclosure can be put together using a plastic bag, several hangers, and some cotton.
- Test Methods
- There are two types of tests: Qualitative and quantitative. The selection of one or both types of tests depends on the severity and extent of the respiratory hazard and the size of the unit or the number of employees involved in wearing respiratory protective devices. During any fitting test, the respirator headstraps must be as comfortable as possible. Tightening the straps sometimes reduces face piece leakage, but the user may be unable to tolerate the respirator for any length of time.

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Fit Checking

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

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Test your knowledge

- Each time a respirator is worn, the use must perform

  - Qualitative fit-tests
  - Quantitative fit-tests
  - Positive and negative pressure checks
  - Qualitative fit-test and quantitative fit-tests

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Summary

- 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/MSHA approved.
  - Do no 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 no affect the seal between the face piece 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.

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- You have completed the module:
  - Respiratory Protection

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