Personal Protective Equipment Participant Manual

June 2016

Acknowledgments

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See http://med.uc.edu/eh/academics/training/mwcfor a listing of contacts at each member institution and additional information. We encourage you to comment on these materials. Please give your suggestions to those teaching the program in which you are now enrolled, or forward them to the Midwest Consortium for Hazardous Waste Worker Training, University of Cincinnati, P.O. Box 670056, Cincinnati, Ohio 45267-0056 or click on ‘contact us’ at http://med.uc.edu/eh/academics/training/mwc

Warning

 The material was prepared for use by facilitators experienced in the training of persons who are or who anticipate being employed at a worksite requiring use of personal protective equipment. Authors of this material have prepared it for the training of this category of workers as of the date specified on the title page. Users are cautioned that the subject is constantly evolving. Therefore, the material may require additions, deletions, or modifications to incorporate the effects of that evolution occurring after the date of this material preparation.

Disclaimer

The Occupational Safety and Health Administration (OSHA) rules help assure worker health and safety at work sites and during a range of emergency response activities that may require use of provided protective equipment as part of exposure control programs. This program is intended to increase skills of those using personal protective equipment.

Additional training is necessary to perform many activities. These activities include selecting, maintaining and repairing personal protective equipment. Seek guidance on these activities by consulting health and safety personnel and reviewing the PPE program at your worksite.

For information about this matter, consult the training facilitator or your company health and safety representative.

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Introduction

The purpose of PPE is to shield or isolate individuals from the chemical, physical, and biological hazards that may be encountered at a work place.

Objectives

When you have completed this program, you will be better able to:

- Describe the hierarchy of controls.
- Provide an overview of requirements for PPE programs
- Describe employer responsibilities for employee-owned PPE
- Describe employee responsibilities for use of PPE

The Occupational Safety and Health Administration (OSHA) requires that employers perform a job hazard analysis and determine if PPE should be used to protect the worker from exposures. Careful selection and use of adequate PPE should protect the respiratory system, skin, eyes, ears, face, hands, feet, and head. OSHA also requires that the selected personal protective equipment must fit the employee who is utilizing it; this can be accomplished by having several sizes. For example, not everyone can wear the same size of gloves; different sizes of coveralls are needed for a man who is 6 feet tall and a woman who is 5 feet tall, even if the waist sizes are the same.

In those cases where it is required, the employer is required to provide and pay for personal protective equipment. The exception is that the employer is not required to pay for PPE that can be used away from the worksite, such as prescription safety glasses and safety shoes.

Personal protective equipment is the last choice in the Hierarchy of Controls to prevent exposure.

Hierarchy of Controls for hazard reduction

Control	Highest preference
Eliminate	↓
Substitute	
Prevent	
Modify	
Contain	
Ventilate	
Work Practice Change	
Personal Protective Equipment	Lowest preference

This scheme illustrates that the best and surest approaches to control hazards is to eliminate the exposure or substitute a less toxic material or hazardous process.

The prevention strategies rely on modifying the process, contain (build a box), removing through ventilation, a change in work practice that must be done diligently (day after day by everyone) or use of personal protective equipment (may not be 100% effective even when used diligently; require proper selection, training, cleaning and maintenance).

Work practice controls are often written described in written programs (called administrative controls) that detail how work is to be done or the duration that someone can work in a particular area. For example, an administrative control for noise is to limit the duration of exposure.

Personal Protective Equipment – General Requirements

OSHA provides the following general requirements for PPE:

- Provided, used and maintained in a sanitary and reliable condition when needed to prevent hazards that might injury or impairment in the function of any body part through absorption, inhalation or physical contact.
- If employee-owned PPE is used, the employer shall assure it is adequate, including proper maintenance and sanitation.
- Must be safe and designed for the work to be performed.
- Selection is based on a written hazard assessment, protective for the hazards, known to the employees, fit to the employee
- Training includes:
    - When and what PPE is necessary
    - Proper procedures to don/doff/adjust/wear
    - Limitations
    - Proper care, use maintenance, useful life, disposal

  - Before use, employee shall demonstrate understanding of the training, ability to use PPE properly; retraining is conduced when needed.

- Employer pays for PPE <u>except</u>
  - Non-specialty PPE that the employee can wear off site.
  - Metatarsal protection in shoes, when the employer provides metatarsal guards
  - Logging boots
  - Every-day clothing
  - Ordinary creams such as sun screen
  - Replacement due to loss or intentional damage

See 29 CFR 1910.132 Personal Protective Equipment—General Requirements. An overview is shown in the OSHA Publication 'Personal Protective Equipment' at https://www.osha.gov/Publications/osha3151.pdf

Personal Protective Equipment –More Specific Program Requirements

In some standards such as the HAZWOPER (29 CFR 1910.120) detailed programs are described when personal protective equipment is required.

The written program for use of PPE contains:

- Selection, based on a hazard assessment.
- Use and limitations.
- Work task duration.
- Maintenance and storage.
- Decontamination and disposal.

- Training and proper fitting.
- Donning and doffing procedures prior to, during, and after use.
- Inspection procedures.
- Evaluation of the effectiveness of the PPE program.
- Special limitations during temperature extremes, heat stress, and other appropriate medical considerations.
- Medical restrictions or physical requirements
- Provision for taking defective or damaged equipment out of service

The employer must communicate the need for the PPE and how it was selected to each affected employee and assure that each worker is trained in the following prior to work:

- What is necessary
- Proper procedures to don/doff, adjust and wear
- Limitations
- Proper care, maintenance, useful life and disposal

Procedures provided by a manufacturer should be followed exactly. They may be incorporated into the written programs. If worksite hazards are unknown, OSHA mandates the highest level of protection, along with the use of special equipment to monitor the air. This is described in Chemical Protective Clothing.

PPE must be properly selected and used to prevent or limit exposure

Respiratory Protection

Respiratory protective equipment (RPE) includes specific equipment to limit inhalation of toxic dusts, gases and vapors. Respiratory protection is required at many work sites where adequate protection cannot be provided through the use of engineering or administrative controls. OSHA Standard 29 CFR 1910.134 requires that a written respiratory protection program be developed by the employer where respirators are necessary to protect an employee's health or required by the employer. Different types of respiratory protection equipment, their use and care, limitations and the required medical exam are discussed. The opportunity is presented to work with several types of respiratory protection.

Objectives

When you have completed this section, you will be better able to:

- Describe the appropriate uses for respiratory protection.
- Evaluate scenarios to determine if respiratory protection is required.
- Identify the requirements of a respiratory protection program.
- Demonstrate donning and doffing of respirators.
- Identify the elements of respirator training that should be provided by the employer.

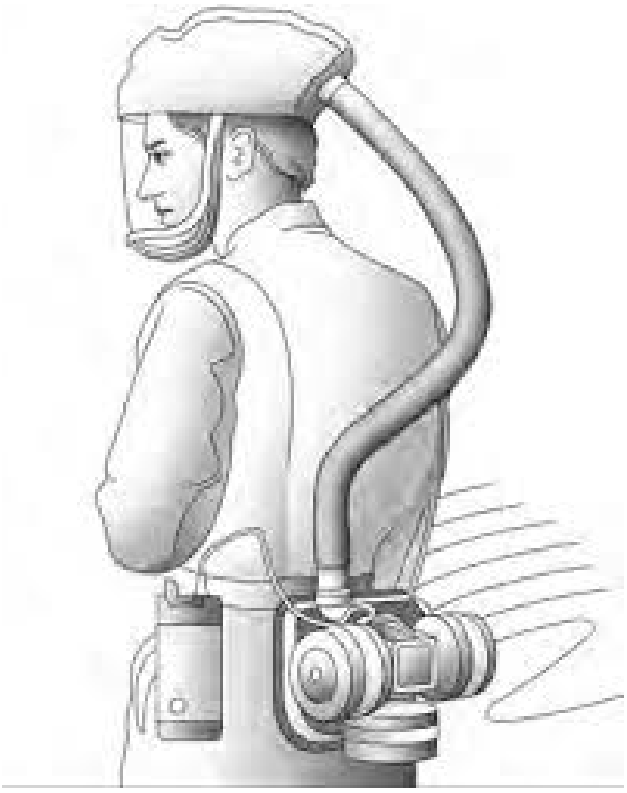
Respiratory Protection

Different types of hazards require different types of respirators. A number of factors should be considered when selecting a respirator. Respirator types and considerations in respirator selection are presented in the following sections. Selecting the appropriate respirator is the responsibility of designated personnel.

Types of Respirators

Two basic types of respiratory protection are:

- **Air-Purifying Respirator (APR)**, which protects against toxic dusts, gases, and vapors by removing the contaminant from the air before it enters the lungs. APRs include negative pressure and Powered Air Purifying Respirators (PAPR).



Powered Air Purifying Respirator (PAPR) (image from OSHA.gov)

- **Atmosphere-Supplying Respirator (ASR)**, which provides “breathing air from a source independent of the ambient atmosphere.” ASRs include supplied-air respirators (SAR) and self-contained breathing apparatus (SCBA).

Supplied-air respirator (SAR) with escape bottle

Self-contained breathing apparatus (SCBA)

Images from OSHA.gov

Each is detailed further below.

Air-Purifying Respirators

Air-Purifying Respirators (APRs) are used to protect against specific dusts and toxic chemicals. They work by removing the contaminant by filtering, adsorbing, or reacting with the contaminated air before it is inhaled. If APRs are used:

- all toxic substances must be identified;
- the concentration must be known and remain constant, verified by monitoring;
- the respirator and cartridge must be selected to protect against those specific chemicals; and

- the oxygen concentration must be greater than 19.5%.

APRs can be reusable or single-use. Reusable APRs consist of a facepiece with an exhalation valve and one or two filtering cartridges through which the air enters. The most widely used facepieces are full-face or half-mask. Full-face and half-mask respirators are illustrated below. Single-use types are typically filtering-facepiece respirators, often known as dust masks.

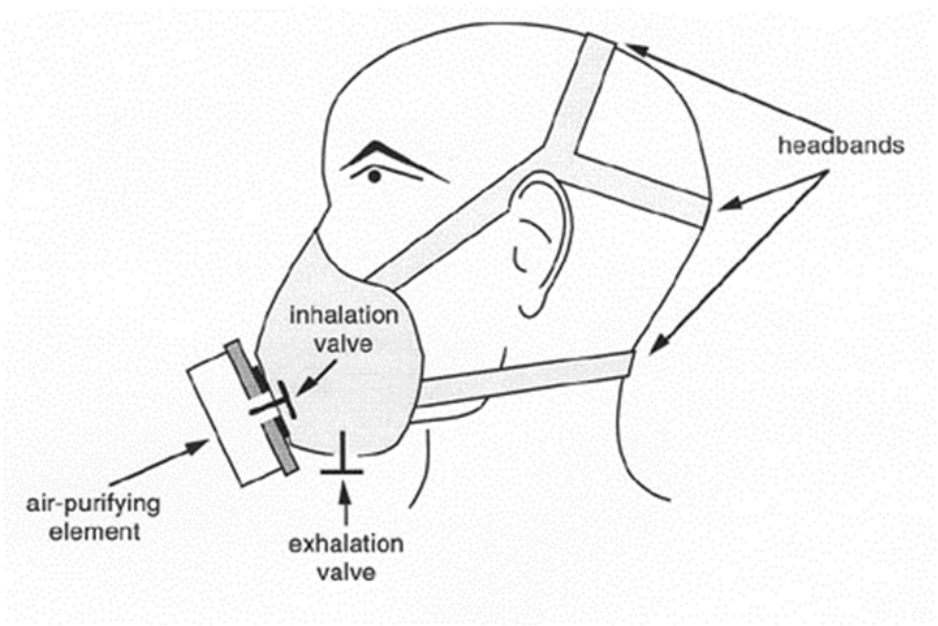
APRs cannot be used in an IDLH atmosphere.

Full Face Air Purifying Respirator

Half Face Air Purifying Respirator

Operation of a Reusable Air-Purifying Respirator

Air enters through the cartridges and exits through an exhalation valve. Note the proper placement of the headbands for a half-mask respirator. Reusable half-mask respirators without the head harness (only two single straps) must not be used.



Filters and Cartridges

Two types of air-purifying elements are used with APRs:

- **Particulate filters** are used to protect against dusts, mists, and fumes.
- **Chemical cartridges** are used to protect against certain vapors and gases.

Filters and cartridges are selected according to specific exposures which are expected. Factors which affect how well the APR works include the size of the particles, concentration of the substance, and type of filter used. The filter(s) must be changed when loaded with the dust (particulate) or substance (chemical cartridge) or if it gets wet. Certain contaminants do not have an appropriate protective cartridge/canister due to their oxygen displacement characteristics or the fact that they are known or suspected carcinogens.

Cartridge and filter colors designate what type of particulates or chemicals are filtered. OSHA regulation 29 CFR 1910.134 dictates the colors that may be used. The table below lists OSHA-approved color and protection combinations.

Contaminants to be Protected Against	Color 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, except tritium & noble gases	Purple (magenta)
Pesticides	Organic vapor canister & a particulate filter
Multi-Contaminant and CBRN agent	Olive
Any particulates - P100	Purple
Any particulates - P95, P99, R95, R99, R100	Orange
Any particulates free of oil - N95, N99, or N100	Teal

[1]Gray shall not be assigned as 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.

Chemical Cartridges

How do you tell if the cartridge needs to be changed? The respirator standard, 1910.134(d)(3), requires that respirators used to prevent gas or vapor exposures be equipped with an indicator showing that the cartridge (certified by NIOSH for the contaminant) has expired; this is called an End-of-Service-Life Indicator (ESLI). It is rare to find an ESLI on a cartridge. If no cartridge approved for a specific gas/vapor exposure has an ESLI, then the employer must use objective data to determine a change schedule and describe it in the written respiratory protection program. Should you detect contaminant before the cartridge has “officially expired,” notify the supervisor immediately and change the cartridge. For dust, a wearer may also notice that it is more difficult to breathe as the filter becomes loaded.

The person responsible for establishing a change-out schedule for chemical cartridges shall consider temperature, humidity, contaminate concentration, and work rate. For some chemicals at high concentrations, the change-out schedule may make the use of air purifying respirators impractical.

Particulate Filters

There are nine classes of particulate filters which are broken down into three series: N, R, and P. Each series (N, R, and P) is available at three levels, based on their efficiency for filtering out the most difficult size of particulate: 95%, 99%, and 99.97%.

N series	No oil
R series	Oil resistant, one shift only
P series	Oil proof, reusable

Other Reusable APRs

Gas masks are a special type of APR that consists of a full facepiece and a canister containing sorbent material. These masks typically protect against organic vapors, acid gases, ammonia, and certain combinations. Gas masks usually have more purifying elements in the canister than the chemical cartridges described above.

Another special type of APR is a **Powered Air-Purifying Respirator** (PAPR), which pulls air through the chemical cartridges or filters and blows it into the facepiece, as shown on the right. The units use a powered fan to achieve the airflow through filters or cartridges to the facepiece. The type of air purifying element must match the contaminant(s) to which the workers are being exposed. PAPRs consist of a hood or helmet, or tight-fitting facepiece, filter and/or cartridge, and power source.

PAPRs can be used only in environments where the oxygen concentration ranges from 19.5% to 23.5%. Typically filters will need to be replaced more often than a non-powered filter.

Single-Use (Disposable) APRs

In a single-use APR (filtering facepiece or dust mask), the entire respirator is made up of filter material, as shown on the right. It may or may not include an exhalation valve. Filtering facepieces are classified according to the N/R/P and 95/99/99.97 system discussed above. The N95 version is very commonly used. Points to remember are that single-use APRs, just like reusable APRs, must be fit-tested (if used to control exposure); surgical masks are not respirators and do not provide the same protection as single-use APRs. Fit-testing will be discussed in a later section.

Atmosphere-Supplying Respirators (ASR)

ASRs may have air supplied from a remote source (supplied air) or from a bottle or tank carried by the user (self-contained) as described below.

Supplied-Air Respirators (SAR)

A supplied-air respirator (SAR) provides a minimum Grade D breathing air to the worker from a stationary tank or other source through air lines. When using an SAR, the worker must wear (not carry) an escape bottle containing a minimum of 5 minutes of air. This escape bottle, or egress unit, is required to allow the worker time to escape if air supply is interrupted.

Escape bottle (image from OSHA.gov)

There are three classifications of supplied air respirators:

- Hose mask with blower (Type A).
- Hose mask without blower (Type B).
- Air-line respirators (Type C).

Air-line respirator (Type C) (image from DOT.gov)

Air-line respirators must operate in either **continuous-flow** or **pressure-demand** mode. In continuous –flow mode, air is always flowing, even when the wearer is not inhaling. In pressure-demand mode, a constant positive pressure is maintained inside the facepiece. Air flows when the positive pressure in the facepiece is reduced as the wearer inhales. A third mode of operation is **demand mode**, in which air only flows when the pressure inside the facepiece becomes negative due to the wearer inhaling. Demand mode provides the least protection, because contaminants can leak into a poorly sealed facepiece when the pressure becomes negative. NOTE: Not allowed in unknown or IDLH concentrations.

Compressors used to supply air must meet special requirements. Compressor exhaust and lubricants must not contaminate the air they supply. Compressor air intakes must be located in a contaminant-free area. (29CFR1910.134(i).

Self-Contained Breathing Apparatus (SCBA)

A self-contained breathing apparatus is an atmosphere-supplying respirator where the breathing air is designed to be carried by the user. A self-contained breathing apparatus is used when extremely toxic chemicals are present, in an oxygen-deficient atmosphere, or when the contaminant or concentration is not known. SCBAs are also typically used in emergency situations.

SCBAs consist of:

- **bottle (tank or cylinder)** contains compressed breathing air (2216psi-5500psi)
- **harness** secures cylinder and connects user to apparatus
- **gauge** displays current cylinder pressure
- **safety/by-pass valve** by-passes the regulator in case of malfunction of the regulator. The by-pass valve should be open only when needed.
- **pressure regulator(s)** provide reduced pressure air during inhalation.
- **full facepiece** isolates user's face from exterior environment

The SCBA is equipped with an alarm to warn the wearer when air in the tank falls below 25% of capacity (2013 edition of NFPA 1981 specifies a 33% capacity alarm). Most SCBAs operate in an open-circuit mode; that is, the exhaled air is vented to the atmosphere and not re-breathed.

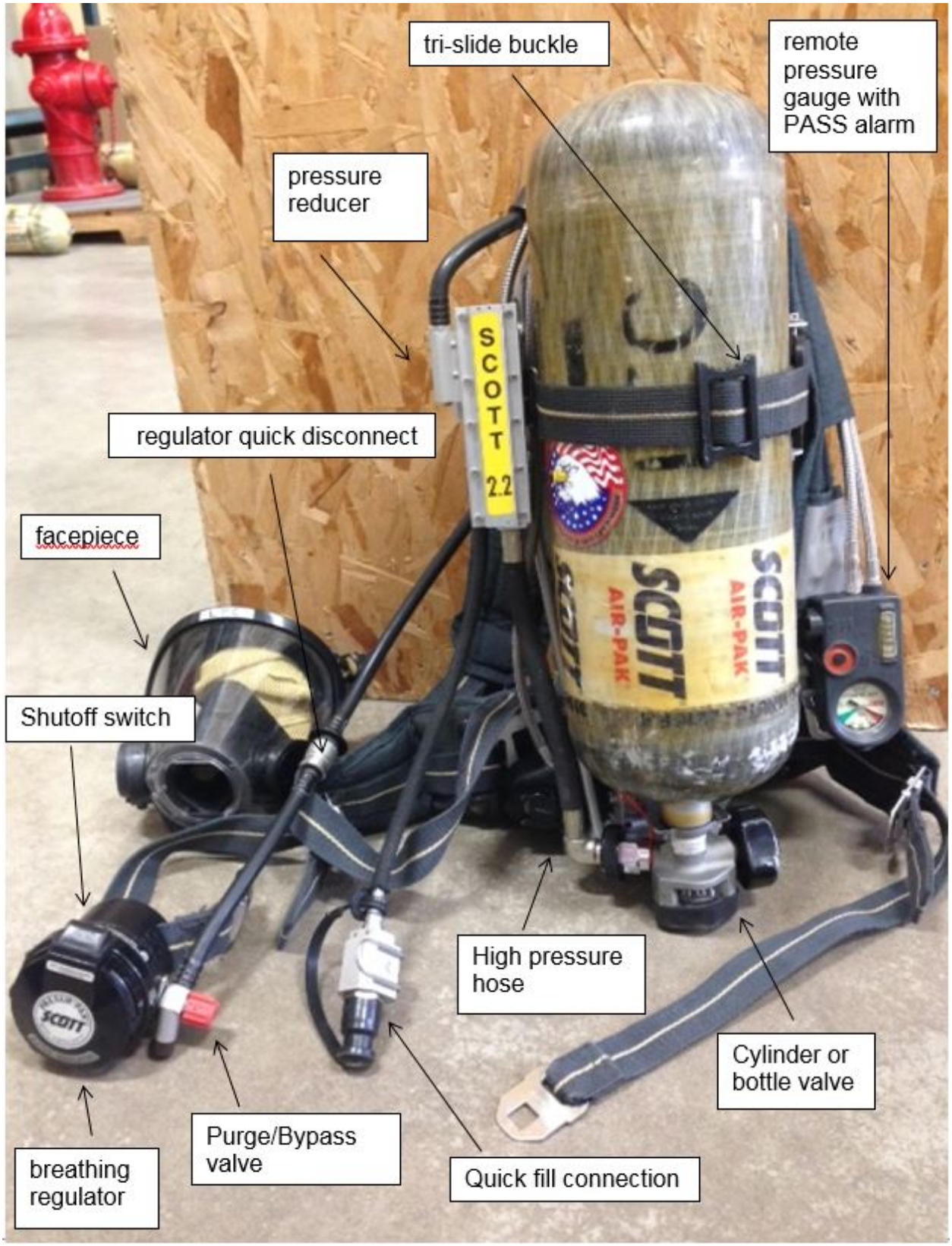
SCBAs and cylinders differ by manufacturer and type. You must be trained in the manufacturer's instructions and checkout procedures before using any SCBA. These should be NIOSH certified for IDLH full facepiece with a minimum duration of 30 minutes or combined with SAR with auxiliary SCBA escape bottle. SCBA can operate in either demand mode (less protective) or pressure-demand mode. SCBA cylinders may be constructed of steel, aluminum, or composite materials. These have varying service lives and hydrostatic testing requirements. Users should familiarize themselves with their specific cylinders. **A positive-pressure SCBA or positive-pressure air-line respirator equipped with an escape air supply must be used when exposure levels are likely to present an IDLH situation or impair ability to escape.**

The equipment should be donned according to the manufacturer's recommended procedures. Workers must be trained for the type of SCBA which will be used. Routine training and practice are especially important for workers who may use this equipment infrequently.

- When the contaminant is unknown, wear a pressure-demand SCBA with a full-facepiece, or a pressure-demand SAR with a full-facepiece in combination with an auxiliary pressure-demand SCBA.

- Auxiliary SCBA must be of sufficient duration to permit escape to safety if the air supply is interrupted.

Certain contaminants are covered by individual standards that cover respirator selection and use. A list of these contaminants may be found at: https://www.osha.gov/SLTC/etools/respiratory/advisor_genius_nrdl/substances.html
For any questions on PPE use, the NIOSH Personal Protective Technology Laboratory (NPPTL) may be contacted at 888-654-2294, or emailed at PPEConcerns@cdc.gov.


tri-slide buckle
remote pressure gauge with PASS alarm
pressure reducer
regulator quick disconnect
facepiece
Shutoff switch
High pressure hose
Cylinder or bottle valve
Purge/Bypass valve
breathing regulator
Quick fill connection
SCOTT
2.2
SCOTT
AIR-PAK

Respirator Fit

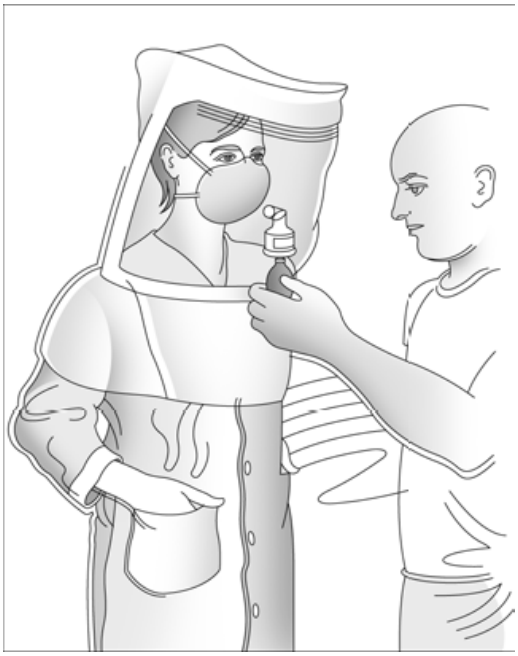
A respirator will be effective only if there is a good seal between the facepiece and the wearer's face. Therefore, all persons wearing respirators must first be fit-tested. Fit-testing includes qualitative or quantitative testing, as well as routine positive-and negative-pressure fit checks.

Because many different face shapes exist, the manufacturers have a number of sizes. The purpose of fit testing is to find the manufacturer/size combination which offers the best protection. Factors such as beards, weight loss or gain, dentures, dental work, or facial injury can change the shape of the face, thus potentially changing the fit and efficiency of the respirator. If any of these factors exist, retesting is required. There shall be no facial hair in the area of the respirator seal.

A protection factor has been determined in the laboratory for each type of respirator (APR, PAPR, SCBA, etc.) and mask (half or full-face). Never assume you will get this much protection. That is why fit-testing is required.

Annual Fit-Tests

Two types of fit-testing, **qualitative** and **quantitative** may be used to determine the size and model of respirator that an individual should wear, as well as how good the face-to-facepiece seal is. These tests should be repeated annually to document the respirator's effectiveness. Fit tests **shall not** be performed if facial hair is present in the seal area of the respirator. (OSHA 29CFR1910.134)



Qualitative Testing

Purpose: Checks effectiveness of preventing substances from entering the facepiece.

Method: While the individual is wearing a respirator, a test substance is released, as shown on the right. The test substance could be smelly (banana oil), sweet (saccharin), bitter (Bitrex) or an irritant (special smoke tube). The wearer should not be able to detect the substance while performing a series of prescribed tasks.

Requirements: This test or its equivalent is required by OSHA at least once a year.

There are several important cautions to qualitative fit-testing:

- Some of the test substances may irritate the eyes or cause coughing.
- A sensitivity test is first performed to determine the individual is capable of sensing the test solution.
- Fit-testing is often done in “ideal” environments. The fit may change after wearing the respirator several hours or during strenuous activity.
- Must be used only for Fit Factor (described later) ≤ 100.

Note: This method is not appropriate for SCBA facepieces. A quantitative method must be used.

Quantitative (Numerical) Testing

This test provides an objective assessment of the effectiveness of the respirator for the person who will wear it. This test measures the fit factor (FF), which is a comparison of the concentration of the substance outside of the mask to the concentration of the substance inside of the mask. This FF is useful in determining whether the respirator will effectively protect the wearer from specific chemicals. A disadvantage to this test is that special equipment and trained personnel are needed to administer it, although a computer and software can perform the calculations required.

Purpose: Measures effectiveness of the respirator in preventing a substance from entering the facepiece.

Methods: There are two methods for quantitative fit testing based on the fit testing device.

Photo courtesy of TSI Inc. to MWC.

1. While an individual wears a respirator modified with a probe, the concentrations of particulates in the air inside and outside of the respirator are measured, as shown on the right. The test is repeated while the person performs specific tasks (speaking, running in place, etc.) that may affect fit.

2. While an individual wears a respirator connected to a fit testing device, a vacuum is drawn in the mask to assess seal for leaks. Then the user removes and redons the mask and the test is repeated twice.

Requirements: This test is mandated when a minimum fit factor of 50 for a full face mask APR is required.

Routine User Checks

Two types of user seal checks, **positive**- and **negative**-pressure checks, should be done each time a respirator is donned and before each use in the field to check the seal of the respirator. They do not replace yearly fitting but provide a routine assessment as to whether the fit is still adequate.

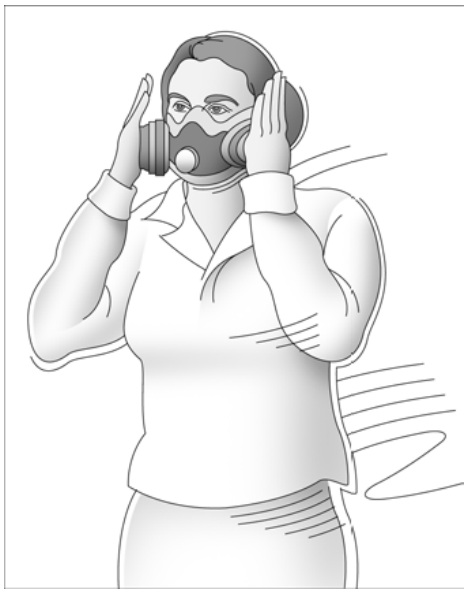
Positive-Pressure Check

Purpose: Checks the facepiece components for leaks at valves or other points. NOTE: Not all positive-pressure respirators allow easy access to the exhalation valve for this test.

Method: Close off the exhalation valve (if possible) and exhale gently into the facepiece. The face fit is considered satisfactory if a slight positive pressure can be built up inside the facepiece without any evidence of outward leakage of air at the seal. For most respirators this method of leak testing requires the wearer to first remove the exhalation valve cover before closing off the exhalation valve and then carefully replacing it after the test. This is only performed if the cover can be manually removed.

Requirements: Shall be done before each use.

Negative-Pressure Check



Purpose: Checks the facepiece-to-face seal.

Method: SCBA wearer disconnects the regulator and places hands over the hole for the regulator connection and inhales. APR wearer places hands over cartridges and inhales, as shown on the right. No outside air should be felt leaking into the facepiece.

Requirements: Shall be done each time the respirator is donned (first use, break, lunch).

Positive- and negative-pressure checks can be done quickly and easily in the field. If the wearer is unable block the holes or cartridges with their hands, additional measures may need to be performed to accomplish the blocking requirement to detect the leaks.

Assigned Protection Factors

Respirators are selected by using Assigned protection factors (APFs). The higher the APF, the more protective the respirator is. These protection factors are set after testing by NIOSH and are subject to change. Protection factors vary according to the particular respirator type. Following is a list of APFs:

Assigned Protection Factors (APFs)					
Type of Respirator	**Quarter mask***	**Half mask**	**Full facepiece**	**Helmet/Hood**	**Loose-fitting facepiece**
1. Air-purifying Respirator	5	10	50	-	-
2. Powered Air-purifying Respirator (PAPR)	-	50	1,000	25/1,000	25
3. Supplied-air Respirator (SAR) or Airline Respirator					
• Demand mode	-	10	50	-	-
• Continuous flow mode	-	50	1,000	25/1,000	25
• Pressure-demand or other positive-pressure mode	-	50	1,000	-	-
4. Self-contained Breathing Apparatus (SCBA)					

• Demand mode	-	10	50	50	-
• Pressure-demand or other positive-pressure mode (e.g., open/closed circuit)	-	-	10,000	10,000	-

*Quarter masks are not widely used, and are not discussed as part of this course.

Protection factors also exist for combinations of the above respirators. For example, an SAR with a full-face mask and an auxiliary SCBA equals 10,000.

The use of these APFs presumes that the facepiece has been properly selected to provide the best possible fit. These factors do not apply for persons with facial hair as it interferes with the seal of the facepiece. The APFs still apply when choosing a respirator but a person with facial hair that interferes is required to utilize a hood type system and the APF for that is low.

Fit Factor Calculation

Proper selection of respirators can be accomplished by dividing the known chemical concentration by the APF. The resulting value needs to be compared to the occupational exposure guideline used by your employer.

$$\frac{measured\ chemical\ concentration\ (ppm)}{APF} = parts\ per\ million\ (ppm)$$

If the calculated ppm is higher than the exposure guideline, then that type of respiratory protection would be inadequate. If the calculated ppm is lower than the exposure guideline, then that type of respiratory protection should be sufficient, provided that the measured concentration will not increase, and provided that the measured chemical concentration is below the IDLH concentration, if using an APR.

Sample Fit Factor Calculation: Cyclohexene may be released from drums. The safety and health officer measured an 8-hour TWA concentration of 400 ppm of cyclohexene, but OSHA PEL is 300 ppm for an 8-hour work shift. Because engineering controls cannot be implemented, respiratory protection must be used. What type of respiratory protection would provide adequate protection against this contaminant?

Formula: $$\frac{measured\ chemical\ concentration\ (ppm)}{APF} = ppm$$

First, use the table of APFs to see if a half-face APR can be used:

$$\frac{400\ ppm}{10} = 40\ ppm$$

The resulting answer is 40 ppm, which means that 40 ppm of cyclohexene could be present inside the facepiece of a properly fitted respirator. A concentration of 40 ppm is less than the OSHA 300 ppm PEL, so this type of respiratory protection would be adequate. However, the safety and health supervisor questions the fit for all people in the hot sun. See if a full-face APR provides better protection:

$$\frac{400\ ppm}{50} = 8\ ppm$$

The resulting answer is 8 ppm. A properly fitted full-face APR would be sufficient and would protect better than the half-face APR.

Maximum Use Concentration

If the concentration of the contaminant in the workplace rises to a different level, another calculation of fit factor would need to be done to see if the respirator is still protective at the new concentration. Instead, the Maximum Use Concentration (MUC) is sometimes calculated. To calculate the MUC, multiply the PEL (or other exposure guideline) by the APF:

$$MUC = PEL * APF$$

In the example of cyclohexene above, with a half-face APR, the PEL is 300 ppm and the APF is 10:

$$MUC = 300 * 10 = 3000\ ppm$$

Therefore, the half-face APR could be used up to a cyclohexene concentration of 3000 ppm, as long as that concentration is not above the IDLH. Checking the NIOSH Pocket Guide, the IDLH for cyclohexene is 2000 ppm. An APR cannot be used above the IDLH, so the MUC would only be 2000 ppm. Always check the IDLH when calculating the MUC.

Calculating the MUC for the full-face APR, you get:

$$MUC = 300 * 50 = 15{,}000\ ppm$$

Once again, you cannot use an APR above the IDLH, therefore the MUC for cyclohexene for the full-face APR would also be 2000 ppm.

Exercise - Respiratory Protection Factor

In this exercise, you will work in groups to calculate whether a respirator provides protection in a given atmosphere. (See Exercise Manual)

Cleaning, Storage, Inspection and Maintenance of Respirators

Proper inspection, maintenance, and storage are essential to assure that the respirator is always ready for use. The OSHA respirator standard requires employers to provide for the cleaning and disinfection, storage, inspection and repair of respirators used by employees. Always consult manufacturers' recommendations for use, care and maintenance also.

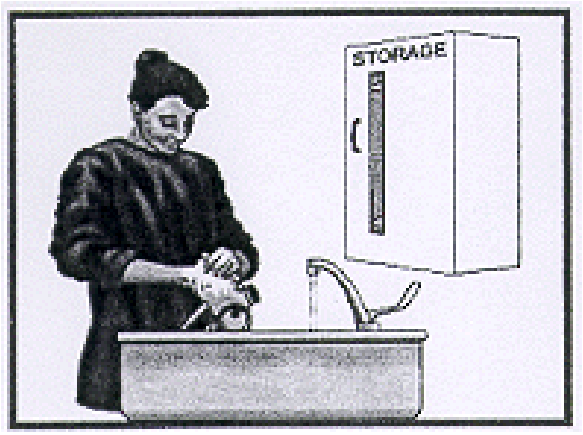
Cleaning respirators

Appendix B-2 to 29 CFR 1910.134 requires the following respirator cleaning procedures. Manufacturers' recommendations may be used as an alternative, provided that they are at least as effective as those specified here:

A. Remove filters, cartridges, or canisters. Disassemble facepieces by removing speaking diaphragms, demand and pressure- demand valve assemblies, hoses, or any components recommended by the manufacturer. Discard or repair any defective parts.

B. Wash components in warm (43 deg. C [110 deg. F] maximum) water with a mild detergent or with a cleaner recommended by the manufacturer. A stiff bristle (not wire) brush may be used to facilitate the removal of dirt.

C. Rinse components thoroughly in clean, warm (43 deg. C [110 deg. F] maximum), preferably running water. Drain.



Rinsing respirator (image from OSHA.gov)

D. When the cleaner used does not contain a disinfecting agent, respirator components should be immersed for two minutes in one of the following:

1. Hypochlorite solution (50 ppm of chlorine) made by adding approximately one milliliter (approximately 20 drops) of laundry bleach to one liter of water (about a 1000:1 dilution) at 43 deg. C (110 deg. F); or,

2. Aqueous solution of iodine (50 ppm iodine) made by adding approximately 0.8 milliliters (about 16 drops) of tincture of iodine (6-8 grams ammonium and/or potassium iodide/100 cc of 45% alcohol) to one liter of water (about a 1250:1 dilution) at 43 deg. C (110 deg. F); or,

3. Other commercially available cleansers of equivalent disinfectant quality when used as directed, if their use is recommended or approved by the respirator manufacturer.

E. Rinse components thoroughly in clean, warm (43 deg. C [110 deg. F] maximum), preferably running water. Drain. The importance of thorough rinsing cannot be overemphasized. Detergents or disinfectants that dry on facepieces may result in dermatitis. In addition, some disinfectants may cause deterioration of rubber or corrosion of metal parts if not completely removed.

F. Components should be hand-dried with a clean lint-free cloth or air-dried.

G. Reassemble facepiece, replacing filters, cartridges, and canisters where necessary.

H. Test the respirator to ensure that all components work properly.

Respirators must be cleaned and disinfected after each use, unless they are being used routinely exclusively by the same employee. In that case, they must be cleaned and disinfected as often as needed to be sanitary.

Respirator Storage

OSHA requires that all respirators be stored to protect them from damage, contamination, dust, sunlight, extreme temperatures, excessive moisture, and damaging chemicals, and that they must be packed or stored to prevent deformation of the facepiece and exhalation valve.

Inspection

Respirators must be inspected before and after each use and checked at least monthly, even if the respirator has not been in use. A company policy may include more frequent inspections. OSHA requires that inspections include:

- A check of respirator function
- Tightness of connections
- The condition of the various parts including, but not limited to, the facepiece, head straps, valves, connecting tube, and cartridges, and canisters or filters
- A check of elastomeric parts for pliability and signs of deterioration.

- In addition to the above, self-contained breathing apparatus must be inspected monthly.

- Air and oxygen cylinders must be maintained in a fully charged state and be recharged when the pressure falls to 90% of the manufacturer's recommended pressure level. The employer must determine that the regulator and warning devices function properly.

Maintenance

OSHA requires that defective respirators be removed from service immediately and discarded, or repaired/adjusted as follows:

- Repairs or adjustments must be made only by trained persons, using the manufacturer’s NIOSH-approved parts.

- Repairs must be made according to the manufacturer’s recommendations and specifications.

- Critical parts including reducing and admission valves, regulators and alarms may only be adjusted or repaired by the manufacturer or a technician trained by the manufacturer.

Consult the company respiratory protection program for detailed requirements.

Minimum Requirements for a Respiratory Protection Program

OSHA requires that employers who make respirators available to their employees have a written respiratory protection program with work-specific procedures (29CFR1910.134(c). The program must be evaluated and updated as necessary. Programs shall be updated as requirements change and/or modifications occur that reflect changes in the workplace. OSHA requires the use of NIOSH-approved respirators. Approval numbers will be clearly written on all approved equipment, as shown on the next page, or on written materials shipped with the respirator. Respirators manufactured after 2008 are marked with an approval designation known as a "TC" number. [Example: TC #XXX-XXXX].

A respiratory protection program must include the following points:

- Medical evaluations of employees required to use respirators.
- Fit testing procedures for tight-fitting respirators.
- Procedures for proper use of respirators in routine and reasonably foreseeable emergency situations.
- Procedures and schedules for cleaning, disinfecting, storing, inspecting, repairing, discarding, and otherwise maintaining respirators.
- Procedures to ensure adequate air quality, quantity, and flow of breathing air for atmosphere-supplying respirators.
- Training of employees in the respiratory hazards to which they are potentially exposed during routine and emergency situations.
- Training of employees in the proper use of respirators, including putting on and removing them, any limitations on their use, and their maintenance.
- Procedures for regularly evaluating the effectiveness of the program.

The employer must designate a program administrator who is qualified to oversee the respiratory protection program and conduct the required evaluations of its effectiveness. Respirator training and the required medical evaluations are provided to the employee at no cost. The respiratory protection program also may include:

- Need for corrective lenses in full-facepiece respirators.
- Restriction of use of contact lenses.
- Communication needs.
- Guidelines for use in dangerous atmospheres, including confined spaces.
- Guidelines for use in extreme temperatures.

The respiratory protection program will include a description of who is responsible for the various aspects of the program including selection, periodic and routine fit-testing, inspection, cleaning, repair, and maintenance. Persons using respirators under unusual conditions (e.g., a high concentration of acid vapor) should review special requirements with supervisors or the employee safety and health representatives. For a sample respiratory protection program, see:
http://www.osha.gov/dcsp/compliance_assistance/sampleprograms.html#Respiratory Protection

Medical Fitness to Wear a Respirator

Before an employee receives clearance to wear a respirator, a medical evaluation must be performed by a physician or other licensed health care professional (PLHCP), as described in 29CFR1910.134(e). The evaluation helps assure that the employee is physically capable of working with the added physical stress of a respirator. Any follow-up evaluations and testing will be determined by the PLHCP.

Some medical conditions which may prevent an individual from wearing a respirator include:

- Lung disease.
- Claustrophobia.
- Severe high blood pressure.
- Heart disease.

Other conditions that should be considered when wearing a specific type of respirator include:

- Contact lenses.
- Eyeglasses.
- Moustache.
- Perforated tympanic membrane (ruptured eardrum).

Special eyeglass kits are available for use with full-facepiece respirators.

Exercise– Respiratory Protection Lab

In this exercise, you will become familiar with SCBAs, APRs, egress units and equipment cleaning and inspection procedures. (See Exercise Manual.)

Exercise– Respiratory Protection Scenarios

Working in groups, evaluate the safety of wearing a respirator in given situations. (See Exercise Manual.)

Training – Respiratory Protection

Site-specific RP training should include:

- RP to be used based upon known or anticipated hazards
- Limitations of materials and construction, such as temperature limits, heat stress and other medical considerations
- Use and limitations of respirator equipment as well as documentation procedures outlined in the OSHA respirator standard (29 CFR 1910.134)
- RP inspection procedures before, during and after use
- Donning and doffing procedures
- Decontamination and disposal procedures for RP
- Maintenance and storage of RP
- Effect of RP limitations on task duration

Consult your employer for further information. Respiratory Protection is included in the OSHA resource on 'Program Templates';
see: https://www.osha.gov/dcsp/compliance_assistance/sampleprograms.html

Summary—Respiratory Protection (RP)

Respirators are specific types of RP used to prevent toxic materials from entering the body. The two basic types of respirators are air-purifying respirators (APRs) and atmosphere-supplying respirators (ASRs).

APRs may be reusable or single-use. Reusable APRs consist of a facepiece with an exhalation valve and one or two filtering units through which the air enters. Filters may

be for dust, vapors, or both. APRs may not be used where the identity of the contaminant is unknown or in an IDLH atmosphere.

ASRs may be supplied-air respirators (SARs) or self-contained breathing apparatus (SCBAs). SCBAs consist of a facepiece, supply of air, gauge, and safety valve. If SARs are used, an escape unit must also be worn. Routine training and practice is necessary if SCBAs are used.

Situations which may require the use of respiratory protection include:

- Oxygen deficiency.
- Hazardous substances in the air.
- An atmosphere immediately dangerous to life and health (IDLH).
- Confined-space entry.
- A skin/eye absorption hazard.

A respirator should be selected for use after either qualitative or quantitative fit-testing. Before each use, the wearer should conduct positive- and negative-pressure checks.

Care of respirators includes diligent cleaning, disinfecting, storing and maintenance. Units should be inspected before and after each use or monthly if not used routinely.

A written program is required in any workplace where respirators are or may be used. Special considerations in use of respirators include the need for corrective lenses, communication requirements, and use in dangerous atmospheres.

Persons assigned to wear a respirator must be examined by a physician to ensure fitness.

Chemical Protective Clothing

This section covers several aspects of chemical-protective clothing programs and use, and the levels of PPE ensembles designated by OSHA and EPA.

Objectives

When you have completed this program, you will be better able to:

- Identify use of several types of chemical protective suits
- Identify criteria used for selecting CPC
- Identify the different levels of protection
- Identify ways in which the effectiveness of CPC can be reduced
- Identify the advantages and disadvantages of commonly used chemical resistant materials
- Identify precautions to take while wearing PPE
- Describe the reasons to properly inspect, maintain and store PPE.
- Demonstrate the donning and doffing of a level protection.

Chemical-Protective Clothing

Chemical-Protective Clothing (CPC) consists of special clothing worn to prevent chemicals from coming into contact with the body. CPC generally includes eye/face protection, aprons, boots, gloves, and suits/coveralls. CPC is used to protect employees from both chemical and physical hazards that they are likely to encounter while working. The proper use of CPC can prevent or reduce exposure to a harmful substance. CPC is an important part of a worker's personal protective equipment (PPE).

Chemical-protective clothing is made of special materials. These special materials provide chemical resistance, which means they act as a barrier to keep chemicals from coming in contact with the skin. Different materials provide protection from different types of chemicals. It is important to select CPC which is designed to protect against the specific chemical or type of chemical that may be encountered during work. Otherwise, you might not be protected, even when you think you are.

Types of Chemical-Protective Suits

Chemical-protective suits are of two general types, totally encapsulating and partially encapsulating.

- **Totally Encapsulating Chemical-Protective Suit (TECP)**:

Provides head-to-toe coverage to protect the wearer from chemicals. These suits have special seams and zippers to prevent chemicals from leaking into the suit. These suits have a face shield which is made as part of the hood. They are very bulky to wear, and the wearer can become very hot while working. TECPs are the only vapor-resistant suits. TECP suits protect workers from hazards which are identified during hazard evaluation. TECP suits must pass specific positive-air pressure tests and be capable of preventing inward test gas leakage of more than 0.5%. Specific information about pressure tests can be found in OSHA 1910.120, Appendix A.

- **Partially Encapsulating Chemical-Protective Suit (PECP)**: Provides good protection from chemicals and may or may not have face shields. These suits are used when less skin protection is needed. The hood can either be part of the suit or detached. This type of CPC includes suits which look like totally encapsulating suits but have not passed the manufacturer's pressure test.

Disposable suits, which provide limited protection from chemicals, can be used in conjunction with these chemical-protective suits. These disposable suits can be worn

either on top of other suits to protect them or on the inside of other suits to protect the wearer from chafing.

Selection of CPC and other PPE

Generally, one person or group is responsible for the selection and purchase of protective equipment; however, it is important for everyoneto understand the considerations which go into the selection. The selection process should be detailed in the employer's safety and health plan. Questions about PPE selection may be addressed to the person responsible for the selection.

A hazard assessment with a survey of the facility is useful in developing a list of potential hazards. This list can be used in planning for required PPE. Hazards to take into consideration include:

Impact	Penetration
Compression (roll-over)	Chemical
Heat/cold	Combustible/Harmful dust
Light (optical) radiation	Biologic agents
Sources of electricity	Sources of motion or impact
High temperatures	Chemicals used in the workplace

The type of chemical-protective suits selected will depend on the type and nature of potential exposure. For example, totally encapsulating suits may be required for persons over-packing drums, whereas partially encapsulating suits may be required while operating a remote drum handler. Generally, the level of protection provided will be re-evaluated as additional information is gained. Guidelines for selection of PPE, including CPC suits, are presented in the table on the following page.

CPC Selection Guidelines

Always follow manufacturer's recommendations

Chemical resistance: Different materials are resistant to different chemicals. Management should provide CPC which will provide protection against the chemicals likely to be encountered. This rule is true for whole-body as well as hand and foot protection.

Physical integrity: Construction of the suit is important for the proper functioning of the CPC. Seams and zippers should provide solid barriers to chemicals and should be constructed to provide some flexibility.

Resistance to temperature extremes: Heat and cold can adversely affect CPC. Clothing which will be worn in cold temperatures could crack or become ineffective against chemicals. Likewise, heat may destroy the chemical resistance of clothing or even melt it.

Ability to be cleaned: Clothing must be able to be cleaned and decontaminated after each use. If this is not possible, the clothing must be disposed of after use.

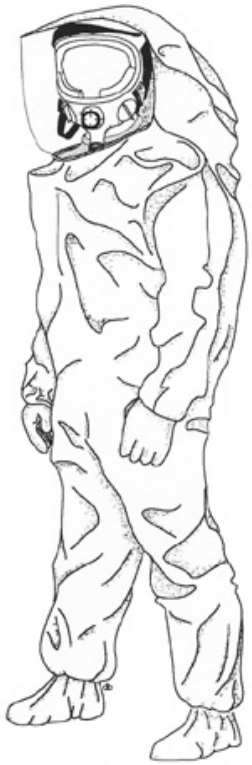
Cost: Initial and ongoing costs of purchasing PPE can be important considerations for management. However, buying less expensive, inferior products which do not adequately protect employees can be more expensive in the long run due to medical costs, lost work time, or, at worst, loss of human life.

Flexibility: Materials need to be flexible enough for the wearer to move and work safely. Overly rigid suits can result in unnecessary accidents from slips, trips, and falls. Gloves which are too rigid may create gripping problems that may lead to other hazards.

Size: CPC should be available in a variety of sizes to accommodate the height and weight of the worker. Suits that are too small will tear easily and provide no protection. Suits that are too large will make walking and/or working difficult. Safety boots that are too big will create both tripping and comfort problems.

Design: CPC should be designed so that all required respiratory PPE can be used at the same time.

Levels of PPE (see 29CFR1910.120, Appendix B)



Level A

Level A is the highest level of protection which can be worn.

What Is Level A Protection?

The following list constitutes Level A equipment; it may be used as appropriate:

- Positive-pressure, pressure-demand, full-facepiece SCBA or positive-pressure, supplied-air to full-face piece with escape SCBA (NIOSH-approved)
- Totally encapsulating chemical-protective suit (TECP) (gas tight or vapor tight)
- Inner and outer chemical-resistant gloves
- Disposable protective suit, gloves, and boots (depending on suit construction, may be worn over totally encapsulating suit)
- Coveralls*
- Long underwear*
- Hard hat (under suit)*
- Chemical-resistant boots with steel toe and shank.
- Cooling system (ice vest, water/air circulation)*

*Optional as applicable
Note: Suit must be properly equipped with a pass-through air-line connection, referred to as an air-line egress if using an SAR.

When Is Level A Protection Needed?

Level A protection is required when:

- The hazardous substance has been identified and requires the highest level of protection for skin, eyes, and respiratory system.
- There is potential for splash, immersion, or exposure to vapors, particulates, or gases that are harmful to the skin or may be absorbed through the skin.
- Confined-space entry may be involved and the need for Level A cannot be ruled out (but explosion hazard has been ruled out).
- The skin absorption hazard may likely result in immediate death or serious illness/injury or impair the ability to escape.

Level B

Level B is used when maximum respiratory protection is desired but the skin/eye hazards do not require Level A.

What Is Level B Protection?

The following constitutes Level B equipment; it may be used as appropriate.

- Positive-pressure, full-facepiece SCBA or positive-pressure, pressure-demand, supplied-air to full-face piece with escape SCBA (NIOSH approved)
- Hooded chemical-resistant clothing **OR** total encapsulating chemical suit (not gas tight or vapor tight)
- Inner and outer chemical-resistant gloves
- Outer chemical-resistant boots with steel toe and shank
- Boot covers: outer, chemical-resistant (disposable)*
- Hard hat*
- Face shield*
- Cooling system (ice vest, water/air circulation)*

New Level B chemical-resistant clothing is designed to go over the SCBA. If appropriate for the potential exposures, this CPC should be used to protect the SCBA and prevent its contamination. In this case, the Level B ensemble will resemble a Level A ensemble, but the suit is not vapor-tight.

*Optional as applicable

When Is Level B Protection Needed?

Level B protection is required when:

- The highest level of respiratory protection is needed but a lower level of skin protection is acceptable
- The substances have been identified
- An SCBA is required
- Less skin protection is needed. (Vapor and gases are not believed to be present at high levels harmful to skin or capable of being absorbed through intact skin.)

Level C

Level C provides less skin and respiratory protection than Level A or B.

What Is Level C Protection?

The following list constitutes Level C equipment; it may be used as appropriate.

- A full-face or half-face air-purifying respirator (NIOSH-approved)
- Hooded chemical-resistant clothing
- Inner and outer chemical-resistant gloves
- Coveralls*
- Boots (outer), chemical-resistant steel toe and shank*
- Boot covers: outer, chemical-resistant (disposable)*
- Hard hat*
- Escape mask*
- Face shield*

*Optional as applicable

When Is Level C Protection Needed?

Level C provides protection when:

- The concentration(s) and type(s) of airborne substance(s) are known and the criteria for using an air-purifying respirator are met.
- Direct contact with the hazardous substance will not harm the skin or the substance will not be absorbed through any exposed skin.
- Air contaminants have been identified, concentrations measured, and an air-purifying respirator is available with an acceptable protection factor
- An adequate level of oxygen (≥ 19.5%) is available and all other criteria for the safe use of air-purifying respirators are met.

Level D

This level offers no respiratory protection and low skin protection.

What Is Level D Protection?

The following list constitutes Level D equipment; it may be used as appropriate.

- Coveralls (work uniform)
- Chemical-resistant boots or shoes with steel toe and shank
- Hard hat*
- Gloves*
- Outer, chemical-resistant boots (disposable)*
- Safety glasses or chemical splash goggles*
- Escape mask*
- Face shield*

*Optional as applicable

When Is Level D Protection Needed?

Level D is required when:

- Minimal protection from chemical exposure is needed. It is worn to prevent nuisance contamination only.
- The atmosphere contains no known hazards.
- Work functions preclude splashes, immersion, or the potential for unexpected inhalation of or contact with hazardous levels of any chemicals.

Typical Uses of Level D Equipment

Level D protection is worn by personnel who may be exposed only to nuisance contamination while working with hazardous materials. Typically, workers involved with support activities such as equipment supply, maintenance, off-site vehicle operation, or supervision/management will wear Level D.

Level D may appear similar to “typical work clothes.” Differences include the chemical-resistant boots with steel shank.

A general rule for which level of protection to use is: **“The less you know, the higher you go.”**

Remembering Levels of Protection
A helpful way to remember the levels of protection is: Level A - ”A”ll Covered, gas/mist tight Level B - ”B”reathing Air, splash protection Level C - ”C”artridge Respirator or air purifying respirator Level D – “D”on’t Expect Protection, regular work clothes

Characteristics and Properties of CPC

PPE is effective only if it’s properly selected, worn, and maintained. Standard Operating Procedures (SOPs) for these types of PPE are included in the safety and health plan. SOPs are company-specific versions of the more general Standard Operating Guides (SOGs) often used in training. SOGs are written instructions for safe work practices and are a form of administrative control.

- Whenever possible, a variety of suit sizes should be on hand to fit the various sizes of personnel.
- The adhesive on tape not approved by the manufacturer may cause degradation of the suit and the warranty may be voided.
- Materials used to make most suits do not “breathe.” Rapid heat and moisture build-up will occur in the suit during use.
- All suits have limits as to the temperature at which they can be worn without damage. This information may be particularly important for emergency response or hot-work activities. Check the manufacturer’s data.
- Most suits offer no fire protection and in some cases increase the possibility of injury because they will melt and may burn.

Penetration, Degradation, and Permeation

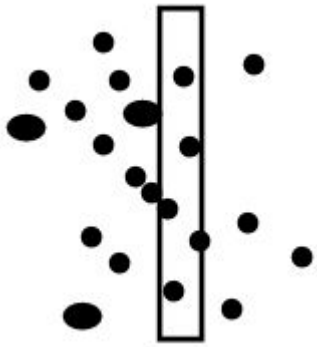
Chemicals can reduce the effectiveness of CPC garments through penetration, degradation, or permeation.

Penetration The flow of a chemical through zippers, stitched seams, or imperfections in the material.

Degradation A reduction in one or more physical properties of a protective material due to contact with a chemical.

Permeation The process by which a chemical moves through a protective material on a molecular level. The rate of permeation is dependent on six major factors:

- Contact time
- Material thickness
- Concentration
- Temperature
- Physical state of chemicals
- Size of the contaminant molecules and pore space



The table on the following page lists and describes some chemical-resistant materials used in CPC and their advantages and disadvantages.

Chemical-Resistant Materials

The following list describes some commonly used chemical-resistant materials and their advantages and disadvantages. Materials for chemical protection may be blended or laminated and require manufacture's data when determining proper selection(s). This list should not be used to select materials; manufacturer's guidelines and other references should be consulted.

Butyl Rubber

Use Mainly in encapsulating suit, but some gloves, boots, and splash gear.

Advantages Good for bases and many organics. Very resistant to gas/vapor permeation. Readily releases contamination. Good heat and ozone resistance.

Disadvantages Poor for aliphatic and aromatic hydrocarbons, gasoline, halogenated hydrocarbons, and abrasion resistance. More expensive than PVC or neoprene.

Chlorinated Polyethylene (CPE)

Use Only in fully encapsulating suits

Advantages Good for aliphatic hydrocarbons, acids and bases, alcohols, and phenols. Resists abrasion and ozone.

Disadvantages Poor for amine, esters, ketones, and halogenated hydrocarbons. Becomes very rigid when cold.

Natural Rubber

Use For boot covers because of durability and for disposable inner and outer gloves.

Advantages Good for bases, alcohols, and dilute acids. Inexpensive. Flexible.

Disadvantages Poor for organic chemicals. Ages (affected by ozone).

continued on the following page

Chemical-Resistant Materials, cont.

Neoprene

Use In all types of protective clothing.

Advantages Better than polyvinyl chloride (PVC) for organics. Durable. Abrasion- and cut-resistant.

Disadvantages Not as good as PVC for acids and bases. Poor for chlorinated aromatic solvents, phenols, and ketones. More expensive than PVC.

Nitrile Rubber

Use In gloves and boots and one encapsulating suit.

Advantage Made specifically for petroleum products. Abrasion- and cut-resistant. Flexible. Good for bases, peroxides, PCBs, phenols, and alcohol.

Disadvantage Poor for aromatic and halogenated hydrocarbons, amines, ketones, and esters. Loses flexibility in cold weather.

Polyurethane

Use In boots and splash gear.

Advantage Good for bases and organic acids, oils, and alcohols. Abrasion-resistant. Flexible (especially in cold weather).

Disadvantage Poor for inorganic acids and other organic solvents.

Polyvinyl Alcohol (PVA)

Use For gloves only.

Advantage Excellent (the best) for oils, aromatic solvents, and chlorinated hydrocarbons. Ozone-resistant.

Disadvantage Degraded by water. Not flexible. Expensive.

continued on the following page

Chemical-Resistant Materials, cont.

Polyvinyl Chloride (PVC)

Use All types of protective clothing.

Advantage Excellent for acids and bases. Very durable. Relatively inexpensive.

Disadvantage Poor for chlorinated and aromatic solvents. Difficult to decontaminate.

Viton

Use In fully encapsulating suits and gloves.

Advantage Good for most organics including chlorinated hydrocarbons. Fair durability. Good for acids. Good for decontamination. Good for physical properties.

Disadvantage Poor for oxygenated solvents—aldehydes, ketones, esters, and ethers. Expensive.

Teflon

Use In fully encapsulating suits.

Advantage Excellent chemical resistance against most chemicals.

Disadvantage Limited permeation test data. Expensive.

Nomex

Use For flame retardant ppe and a base fabric for some suits.

Advantage Acid- and fire-resistant. Durable.

Disadvantage Readily penetrated.

continued on the following page

Chemical-Resistant Materials, cont.

Tyvek®

Use Predominantly for coveralls.

Advantage Dry particulate and dust protection. Disposable, lightweight, and inexpensive.

Disadvantage Penetrable if not chemically treated. Poor durability.

Polyethylene (coated Tyvek®)

Use Predominantly for coveralls, but also gloves and booties. It can be worn over CPC to prevent gross contamination of non-disposables.

Advantage Good for acids and bases, alcohols, phenols, and aldehydes. Good for decontamination (disposable) and lightweight.

Disadvantage Poor for halogenated hydrocarbons, aliphatic and aromatic hydrocarbons. Not very durable. Easily penetrated (stitched seams).

Polyethylene/Ethylene vinyl alcohol (PE/EVAL) – 4H® or Silvershield®

Use Gloves, aprons, sleeves and booties

Advantage Good for alcohols, aliphatics, aromatics, chlorines, ketones and esters, economical

Disadvantage Poor fit of gloves impacts dexterity, easily punctured.

continued on the following page

Chemical-Resistant Materials, cont.

Trellchem®

Use Fully-encapsulating and partially-encapsulating suits

Advantage Resistant to a wide range of chemicals, some models also including chemical warfare agents, abrasion resistance and flame resistance.

Disadvantage Stiff and bulky, expensive

Tychem®

Use Fully-encapsulating and partially-encapsulating suits, coveralls and hoods

Advantage Resistant to a wide range of chemicals, some models also including chemical warfare agents, puncture and abrasion resistance; heat, arc flash and flame resistance.

Disadvantage Expensive, stiff and bulky

A NIOSH website can be used to select materials for CPC.

See: http://www.cdc.gov/niosh/ncpc/

A general rule of thumb is that the permeation rate is inversely proportional to the thickness (2 x thickness = 1/2 x permeation rate). Other important factors are chemical concentration, contact time, temperature, material grade, humidity, and solubility of the material in the chemical.

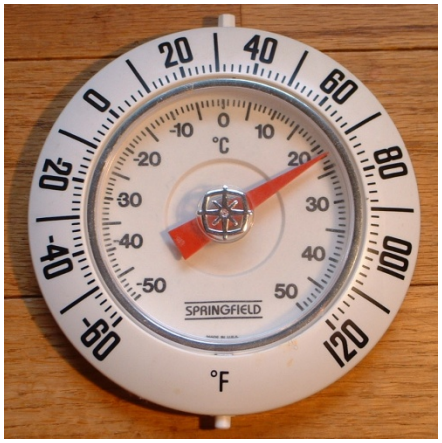
Precautions When Wearing CPC

Every level of chemical-protective clothing has limitations. The following precautions should be considered.

- Hearing and speaking are difficult in CPC with respiratory protection. It is important to establish other ways to communicate with each other. Hand signals or audio signals such as horns, sirens, and whistles can be used to communicate. Communication can also be improved by using two-way radios, such as a portable radio with microphone or radio with a microphone and speaker combination attached to the full-face respirator. Remember, any radio must not add a hazard to the area. Be aware of potential traffic areas.

- Due to the size and weight of some suits, motion is restricted, especially when climbing, working in tight areas, or using hand tools.

- Look for signs of heat stress (dizziness, headache, nausea, perspiration ceases), especially at temperatures over 70ºF.



- Always wear the correct size of footwear in order to prevent accidents. You should also make certain that the soles provide a proper grip for the surfaces that you will be encountering. Steel shanks, toes, and shin guards help to prevent puncture wounds and/or crushing injuries.

- Disposable booties may be slippery. Use caution when walking to prevent slips and falls.

- Care should be taken when donning and doffing inner and outer gloves. When donning gloves, make sure that no cracks or tears are present. When doffing gloves, take care not to spread contamination.

- All joints such as suit-to-boots and suit-to-gloves in Levels B and C protection should be secured with tape. Fold the end of the tape back under to make a tab for easy removal. Use special care when removing tape.

- Goggles and eye/face protection may become clouded due to moisture condensation during use. Use some sort of anti-fog film or spray when needed. When wearing Level A, you may want to keep a cloth inside the suit to wipe fog off the inside face shield.

- Be sure you are adequately hydrated prior to and after use of CPC.

- Avoid placing your hands or knees on the ground when in the Hot Zone to prevent contamination by chemicals and abrasion to the suit material. Avoid sitting on anything sharp in suits.

- When removing a suit, open and fold into itself as it is removed to prevent contamination of internal clothing.

- Suits have weak seams, especially if they are disposable. Be careful not to strain and split them. If splitting occurs, report it and follow the appropriate SOP (standard operating procedure).

- Use caution when suits are used in potential fire areas. If fire occurs, get out of the area.
- When dressing out with a team be careful to coordinate your dress at the same speed and level as your team/buddy. The longer you are dressed out, the more stress is being put on your body.
- Completion of dressout should be delayed until ready to enter the work zone.
- Medical clearance is required for use of respirators.

Exercise– Levels of PPE

Working in groups, identify needed CPC for the scenario. (See Exercise Manual.)

Inspection, Maintenance, and Storage of CPC

It is important to inspect CPC, for evidence of chemical damage. CPC which is torn, degraded, or otherwise non-functional will not offer adequate protection to the wearer. An SOP for CPC inspection, maintenance, and storage assures review whenever:

CPC should always be inspected when it is:

- Received from the distributor
- Issued to workers
- Put into storage
- Taken out of storage
- Used for training
- Used for work or an emergency response
- Sent for maintenance

An inspection checklist should be developed for each item. Factors to consider are:

- Cuts, holes, tears, swelling, and abrasions in seams of fabric
- Weakness in zipper or valve seals
- Signs of contamination such as discolorations or visible chemical residues
- Signs of malfunctioning exhaust valves

Note: CPC may be contaminated even though it doesn't appear discolored.

Proper **maintenance** can prevent CPC deficiencies and prolong its life. A detailed SOP must be developed by the employer and followed rigorously.

Proper **storage** is important in order to prevent suit failures. The written SOP should describe storage before the CPC is issued to the wearer (in a warehouse, on-site, etc.), as well as storage after use. Check the manufacturer's data, as most CPC used now has specific temperature and humidity storage requirements and a shelf life and an expiration date.

Exposure-Specific Protective Clothing

There are specific types of protective clothing that are developed for specific exposures. Those exposures might be high temperature, low temperature, arc flash, welding, diving, flash fire, hazardous equipment, hazardous animals, and etcetera. Equipment designed for a specific exposure may not protect against other types of exposures, such as a chemical exposure. Some of this clothing can be made by the manufacturer to protect against some hazardous materials. Never assume protective clothing will protect for anything it does not specifically state it will protect you for on the manufacturer's information or label.

High-Temperature Clothing: High-temperature clothing may be referred to as flash-over protective suits. At one time, separate flash-over protective suits were worn over other protective clothing, such as CPC, firefighters' turnout gear, or flame-retardant coveralls. Currently, many Level A suits also offer flash fire protection.

Although high-temperature clothing protects against brief exposure to heat, it is not intended for long-term exposure to fire.

Arc Flash Protection: The recent increased awareness of the dangers of arc flash has resulted in an increase in arc flash personal protective equipment (PPE). The materials are tested for their arc rating. The arc rating is the maximum incident energy resistance demonstrated by a material prior to break open (a hole in the material) or necessary to pass through and cause with 50% probability a second or third degree burn. Arc rating is normally expressed in cal/cm² (or small calories of heat energy per square centimeter). The tests for determining arc rating are defined in ASTM F1506 Standard Performance Specification for Flame Resistant Textile Materials for Wearing Apparel for Use by Electrical Workers Exposed to Momentary Electric Arc and Related Thermal Hazards. Among the best fabrics for protection against electric arc flash are the Modacrylic-cotton blends.

Selection of appropriate PPE, given a certain task to be performed, is normally handled in one of two possible ways. The first method is to consult a hazard category classification table, like that found in NFPA 70E. Table 130.7(C)(9)(a) lists a number of typical electrical tasks by various voltage levels and recommends the category of PPE that should be worn. The second method of selecting PPE is to perform an arc flash hazard calculation to determine the available incident arc energy. IEEE 1584 provides a guide to perform these calculations given that the maximum fault current, duration of faults, and other general equipment information is known. Once the incident energy is calculated, the appropriate ensemble of PPE that offers protection greater than the energy available can be selected.

PPE provides protection after an arc flash incident has occurred and should be viewed as the last line of protection. Reducing the frequency and severity of incidents should be the first option and this can be achieved through a complete arc flash hazard assessment and through the application of technology such as high-resistance grounding which has been proven to reduce the frequency and severity of incidents.

Other Protective Clothing and Equipment

Some situations may require other forms of protection. For example, chemical-resistant gloves, face shield/goggles, and apron might be added to Level D when no respiratory hazard but some risk of skin contact exists.

A number of sources (e.g., alarms, machinery) could pose a substantial noise exposure requiring the use of hearing protection. When required, a hearing conservation program must be implemented (OSHA 1910.95). The employer must provide several types of protection from which the worker can choose.

Donning and Doffing PPE

Proper donning and doffing of PPE will preserve the integrity of the PPE and protect the wearer from chemical exposure. An example of a generic Standard Operating Guideline (SOG) for donning Level B PPE is given below

Level B Dress Out (Entrant/Decon) SOG

- Receive medical check (Optional)
- Verify that all PPE is ready and in the dress out area
- Perform an operational check of the SCBA
- Remove watches, jewelry, leather shoes and other personal items
- Don inner suit (Optional)
- Inspect suit
- Don Level B suit to waist.
- Don chemical resistant boots with boot covers.
- Conduct entry briefing.
    - Describe Incident
    - Identify Hazards
    - Assign Duties/Jobs
    - Confirm Equipment and Decon Readiness
    - Confirm Primary, Secondary and Emergency Communications
    - Identify Emergency Showers/Decon
- Don inner glove
- Don middle glove
- Insert arms into the sleeves of the suit and pulling it over shoulders

- Gloves will be turned inside out over the thumb and palm of hand, then carefully taped making sure to stretch the elastic as far as possible and folded back over suit.
- Don chemical resistant outer gloves, and tape seam between glove and suit leaving a tab
- Don facepiece
- Don attached hood of suit, zip up front zipper, attach zipper flap and tape flap leaving a tab
- Don SCBA
- Conduct a positive and negative pressure check of respirator facepiece
- Don hardhat, if required (tape if needed)
- Assign suit number
- Rapid Intervention Team/Decon people to decon line
- Entrant connects regulator to face piece and enters Hot Zone after Decon line is ready and IC approves.
- Ensure wearer is breathing air and indicates readiness with a thumbs-up sign.

The company-specific Standard Operating Procedure will specify the exact units and supplies to be used at the facility.

Exercise – Don, Doff and Inspect Lab

This lab will give you the opportunity to practice donning and doffing different levels of CPC and to inspect it. Checklists are provided to document procedures followed. (See Exercise Manual.)

Summary—Chemical-Protective Clothing

PPE includes respirators, chemical-resistant suits, boots, gloves, chemical goggles, and face shields. PPE is required by OSHA regulations and protects workers from:

- Chemical contact with skin and eyes.
- Noise.
- Temperature.
- Respiratory hazards.

Levels of PPE

Level A provides the most protection and includes:

- A positive-pressure, full-facepiece SCBA or supplied-air respirator with escape unit.
- A totally encapsulating chemical-protective suit (TECP).
- Inner and outer chemical-resistant gloves.
- Chemical-resistant boots with steel toe and shank.

Level B includes:

- A positive-pressure, full-facepiece SCBA or supplied-air respirator with escape unit.
- Hooded, chemical-resistant clothing or non-vapor-tight TECP.
- Inner and outer chemical-resistant gloves.
- Chemical-resistant boots with steel toe and shank.

Level C includes:

- Full- or half-face air-purifying respirator (APR).
- Hooded, chemical-resistant clothing.
- Inner and outer chemical-resistant gloves.
- Chemical-protective boots with steel toe and shank.

Level D includes:

- Coveralls.
- Chemical-resistant boots with steel toe and shank.

CPC materials are not breathable, leading to rapid heat and moisture buildup. CPC may lose its effectiveness through penetration, degradation or permeation.

Different materials protect against exposure to different types of chemicals. The PPE material must be matched to the chemical. Each material has advantages and disadvantages.

Precautions when wearing CPC include:

- Provide for communication
- Be aware of restricted motion and potential for falls
- Watch for signs of heat stress and moisture accumulation
- Wear correct sizes
- Take care when donning and doffing PPE to avoid damage or contamination
- Tape joints for Levels B and C PPE (use manufacturer tape to maintain warranty)
- Avoid contact with puddles of chemicals and sharp or abrasive objects and potential fire areas
- Coordinate dressout with your team

PPE must be properly inspected, maintained and stored. Wearers must know their employer's written program. Written programs about selection, care, and use of PPE are referenced or included in the safety and health plan.

PPE—Other types that may be required

OSHA regulates the use of other PPE that may be used where there is an exposure to hazardous materials. .

Objectives

When you have completed this part of the program, you will be better able to:

- Use resources to find the OSHA requirements for other types of PPE
- Evaluate whether training requirements have been met

Respiratory and chemical protective clothing are important elements of PPE for workers exposed to hazardous materials. However, OSHA also has standards for the following:

Occupational Noise Exposure	29CFR1910.95
Eye and Face Protection	29CFR1910.133
Head Protection	29CFR1910.135
Foot Protection	29CFR1910.136
Electrical Protective Devices	29CFR1910.137
Hand Protection	29CFR1910.138

Exercise – Other PPE Requirements

In this exercise, you will work in groups to complete a work sheet on other PPE requirements. (See Exercise Manual.)

Summary—Other PPE Requirements

OSHA has specific standards for

Occupational Noise Exposure

Eye and Face Protection

Head Protection

Foot Protection

Electrical Protective Devices

Hand Protection

The general Personal Protective Equipment standard (1910.132) requires selection and use of all PPE is based on a documented hazard assessment and specifies the training required for all workers who must use PPE.

CLOSING AND PROGRAM EVALUATION

Thank you for participating in this program.

Take a few minutes to think about what you have learned; the facilitator will make a listing on easel paper.

This is an opportunity to ask any questions you may have, or to discuss how the knowledge and skills learned can be used at work. Were all of your initial questions answered?

Please take the next 10 minutes to complete the program evaluation forms. These are important for improving the program. The Midwest Consortium does take your comments seriously and has made changes in content and the skill exercises based on feedback. Your comments are anonymous.

We hope to see you at another Midwest Consortium program in the future