40-Hr HAZWOPER Module 3

Personal Protective Equipment

Section 3.1 Personal Protective Equipment Basics

The use of Personal Protective Equipment (PPE) is essential when entering hazardous waste sites to protect individuals from potential hazards. PPE is designed to shield individuals from chemical, physical, and biological dangers that may be present. Proper selection and use of PPE can effectively safeguard the respiratory system, skin, eyes, face, hands, feet, head, body, and hearing. This module provides an overview of the different types of PPE suitable for hazardous waste sites and offers guidance on their selection and usage. Additionally, it addresses the importance of considering physiological factors such as heat stress when using PPE.

3.1.1 Compliance with PPE

Compliance with PPE requirements is mandated by OSHA regulations found in 29 CFR Part 1910. Private contractors working on Superfund sites are also obligated to adhere to applicable OSHA provisions and any additional federal or state safety requirements specified by the overseeing lead agency, as outlined in 40 CFR Part 300 by the U.S. Environmental Protection Agency (EPA).

Below is a summary of relevant OSHA Standards (29 CFR 1910) pertaining to PPE usage:

- General Use: 1910.132; 1910.1000; 1910.1001-1045
- Noise Exposure: 1910.95
- Eye, Face, and Respiratory Protection: 1910.133; 1910.134
- Head and Foot Protection: 1910.135; 1910.136
- Electrical Protective Devices: 1910.137

It is important to note that no combination of protective equipment and clothing can protect against all hazards. Therefore, PPE should be utilized in conjunction with other protective measures. It is crucial to recognize that the use of PPE itself can pose significant risks to workers, such as heat stress, physical and psychological stress, impaired vision, mobility, and communication. The level of associated risks generally increases with the extent of PPE protection. However, both over-protection and under-protection can be hazardous and should be avoided.

3.1.2 Developing a PPE Program

It is crucial to establish a written PPE program for work at hazardous waste sites. The primary objectives of such a program are to protect the wearer from safety and health hazards and to prevent injuries resulting from incorrect use or malfunction of the PPE. To accomplish these goals, a comprehensive PPE program should incorporate the following elements:

1. **Hazard identification**: Identify and assess the specific hazards present at the site that require the use of PPE.
2. **Medical monitoring**: Implement a system for monitoring the health of workers who utilize PPE to ensure their well-being and detect any potential adverse effects.

3. **Environmental surveillance**: Regularly monitor the work environment to assess the effectiveness of PPE in reducing exposure to hazards.
4. **Selection, use, maintenance, and decontamination of PPE**: Establish protocols for selecting appropriate PPE based on identified hazards, guidelines for correct usage, procedures for maintenance and decontamination, and guidelines for proper storage.
5. **Training:** Provide comprehensive training to employees on the selection, use, limitations, maintenance, and decontamination of PPE. This training should also cover the recognition of potential hazards and the importance of following safety protocols.

The written PPE program should include policy statements, procedures, and guidelines. Copies of the program should be readily accessible to all employees, with a reference copy available at each work site. It is also important to make technical data, maintenance manuals, relevant regulations, and other essential information easily accessible.

The PPE program should undergo an annual review to ensure its effectiveness. The review should encompass various aspects, including:

- Surveying each site to ensure compliance with relevant regulations
- Evaluating the number of person-hours workers spend wearing different types of protective ensembles
- Analyzing accident and illness records
- Assessing levels of exposure
- Reviewing the adequacy of equipment selection, operational guidelines, decontamination procedures, and maintenance programs
- Evaluating the effectiveness of training and fitting programs
- Coordinating with other elements of the safety and health program
- Assessing the degree to which program objectives are being met
- Reviewing program records
- Making recommendations for program improvement and modification
- Evaluating program costs

The results of the program evaluation should be shared with employees and presented to top management. This allows for the implementation of necessary adaptations and improvements to the program.

Section 3.2 Respirator Protection

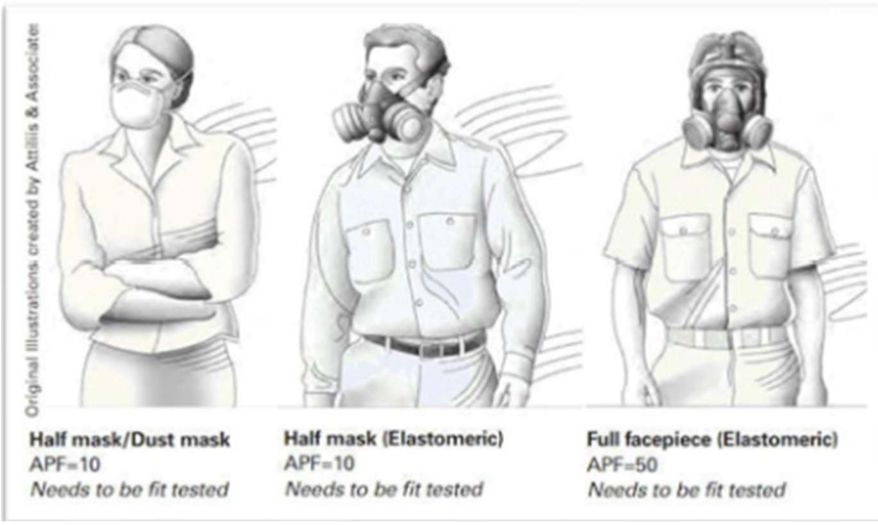
3.2.1 Introduction to Respiratory Protection

Respiratory protective devices are commonly used in various industries to minimize exposure to airborne contaminants and oxygen-deficient atmospheres. Air quality testing and the information from Safety Data Sheets (SDSs) are used to determine the appropriate type of respiratory protection. Respirators should only be used for protection against substances that have been approved for their specific use. It is important to follow proper guidelines for cleaning, disinfecting, and replacing respirators, ensuring the highest level of protection.

Types of Facepieces

Various types of facepieces are available for different respirator models. The commonly used ones at hazardous waste sites are full facepieces and half masks. Full-facepiece masks provide comprehensive coverage from the hairline to below the chin, including protection for the eyes.

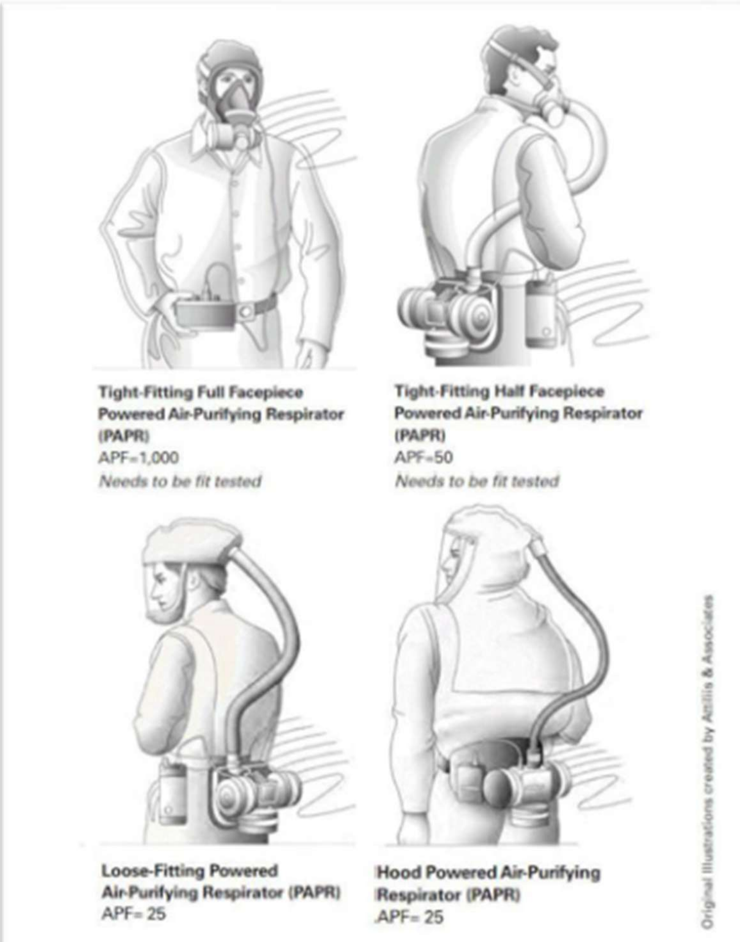
Half masks cover the lower part of the face, extending from below the chin to over the nose. However, it's important to note that half masks do not provide protection for the eyes.



Tight-Fitting vs Loose-Fitting Respirators

Tight-fitting respirators are designed to create a seal with the wearer's face. They come in three types: quarter mask, half mask, and full facepiece. Components of tight-fitting respirators typically include a facepiece, eyepiece (for full-facepiece masks), inhalation and exhalation valves, and an air source or air-purifying element.

On the other hand, **loose-fitting respirators** have a respiratory inlet covering that forms a partial seal with the face. Examples include loose-fitting facepieces, hoods, helmets, blouses, or full suits that completely cover the head. Supplied air hoods used by abrasive blasters are a well-known type of loose-fitting respirator.



Positive-Pressure vs Negative-Pressure Respirators

Respirators can be categorized based on the air flow supplied to the facepiece, either maintaining positive pressure or negative pressure.

Positive-pressure respirators maintain a higher pressure inside the facepiece throughout both inhalation and exhalation. There are two main types of positive-pressure respirators:

- **Pressure-Demand Respirators**: These respirators utilize a pressure regulator and an exhalation valve on the mask to maintain positive pressure. During normal breathing, the mask remains pressurized. However, during high breathing rates or in the event of a leak, a continuous flow of clean air is supplied to the facepiece to prevent contaminated air from entering.
- **Continuous-Flow Respirators**: These respirators deliver a continuous stream of air into the facepiece. The constant flow of air prevents the infiltration of ambient air. However, continuous-flow respirators consume air supply more rapidly compared to pressure-demand respirators.

For example, Powered Air-Purifying Respirators (PAPRs) operate in a positive-pressure continuous-flow mode by using filtered ambient air. While they primarily maintain positive pressure, it's important to note that during maximal breathing rates, a negative pressure may be created momentarily in the facepiece of a PAPR.

Negative-pressure respirators, on the other hand, rely on inhalation to create a negative pressure or vacuum inside the facepiece. When properly fitted, the negative pressure helps draw air through the respirator's filtering elements, ensuring that contaminants are captured before inhalation. However, one significant drawback of these respirators is that if there are any leaks in the system, such as a cracked hose or an improperly fitted mask, the user may inhale contaminated air.

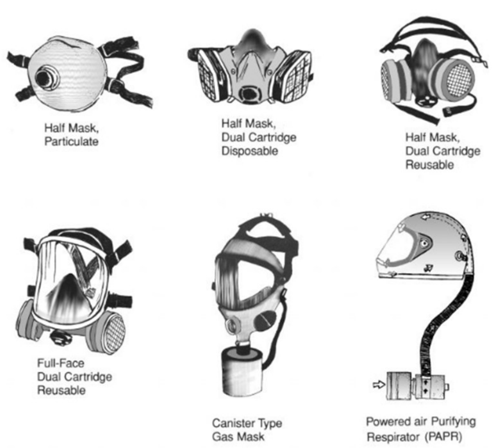
In the following sections, two types of respirators will be discussed: Air-Purifying Respirators and Atmosphere-Supplying Respirators.

3.2.2 Air-Purifying Respirators

Air-Purifying Respirators (APRs) remove airborne contaminants such as particles, toxic vapors, and/or gases. APRs do not have a separate air source but instead utilize ambient air that passes through a filtering element to remove contaminants. APRs can be grouped into three types based on their filtration capabilities:

- Particulate removing
- Vapor and gas removing
- Combination

Filters and chemical cartridges/canisters are the functional components of APRs and can typically be replaced once their effectiveness has expired. However, filtering facepiece respirators (also known as "disposable respirators," "dust masks," or "single-use respirators") cannot be reused after initial use (see picture below courtesy of pesticidestewardship.org).



The efficiency of APRs can vary significantly even among closely related materials. Their use at hazardous waste sites is limited and can only be employed when the ambient atmosphere contains sufficient oxygen (at least 19.5 percent). In addition, there are certain conditions that may exclude the use of APRs, including:

- Oxygen deficiency
- The presence of IDLH concentrations of specific substances
- Entry into unventilated or confined areas with unknown exposure conditions
- The presence or potential presence of unidentified contaminants
- Unknown or excessive concentrations of contaminants exceeding designated maximum use concentrations
- Inadequate warning properties of identified gases or vapors with unknown sorbent service life and no end-of-service-life indicator
- High relative humidity that may reduce the effectiveness of the sorbent.

Cartridges, Canisters, and Filters

There are various types of filtration media for filtering masks including cartridges, canisters and filters. Cartridges are directly attached to the respirator facepiece, while larger-volume canisters are either attached to the chin of the facepiece or carried with a harness and connected to the facepiece through a breathing tube. Combination canisters and cartridges contain layers of different sorbent materials, enabling them to remove multiple chemicals or classes of chemicals from the surrounding air. Filters can also be combined with cartridges to provide additional protection against particulates. Commercially available cartridges and canisters are color-coded to indicate the general chemicals or classes of chemicals against which they are effective.

The respirator cartridge color coding system is further shown in the following image.

RESPIRATOR CARTRIDGE COLOR CODING

Cartridge Color	Cartridge Use
WHITE	Hydrogen Chloride, Sulfur Dioxide, Hydrogen Sulfide
WHITE with 1/2" GREEN stripe completely around bottom canister	Hydrcyanic Acid Vapor
WHITE with 1/2" YELLOW stripe completely around bottom canister	Pure Chlorine
BLACK	Organic Vapors (OV)
YELLOW	Organic Vapors with Hydrogen Chloride, Sulfur Dioxide, Hydrogen Sulfide, or Hydrogen Fluoride
YELLOW with 1/2" BLUE stripe completely around bottom canister	Hydrcyanic Acid and Chloropicrin vapor
GREEN	Ammonia, or Ammonia and Methylamine
GREEN with 1/2" WHITE stripe completely around bottom canister	Ammonia and Acid Gases
CHARTREUSE	Formaldehyde
MAGENTA	Radioactive (Except Noble Gases & Tritium) Particulates (Dusts, Fumes, Fogs, Smoke, and in combination with any above gas or vapor)
BROWN	Multi-gas, or Multi-gas and OV, or Multi-gas and acid gas, or all
ORANGE	Mercury Vapor (Also used as a 1/2" stripe to represent gases not included in this table
BLUE	Carbon Monoxide
RED with 1/2" GRAY stripe completely around top canister	All the above contaminants in one canister

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The use of a sorbent is not permitted if there are doubts about its effectiveness in efficiently absorbing a particular contaminant. Chemical sorbent canisters often have expiration dates marked on them. If unopened, they can be used until the expiration date. However, once opened, they begin to absorb humidity and air contaminants, reducing their efficiency and service life. Therefore, opened canisters should be used immediately.

Cartridges should be discarded after use and should not be used for longer than one shift or when breakthrough occurs, whichever comes first.

Warning properties of substances are crucial for the safe use of Air-Purifying Respirators as they help detect breakthrough of contaminants if it happens. While warning properties are not foolproof due to variations in human senses and conditions like olfactory fatigue, they provide some indication of potential sorbent exhaustion, poor facepiece fit, or other malfunctions. When using a canister or cartridge against gases or vapors, it is essential to ensure that the chemical(s) being encountered have "adequate warning properties."

NIOSH considers a substance to have adequate warning properties when its odor, taste, or irritant effects can be detected and persist at concentrations below the Recommended Exposure Limit (REL). A substance is considered to have poor warning properties when its odor or irritation threshold is higher than the applicable exposure limit. OSHA permits the use of Air-Purifying Respirators for protection against specific chemicals with poor warning properties if either the service life of the sorbent is known and a safety factor has been applied, or the respirator has an approved end-of-service-life indicator.

3.2.3 Atmosphere-Supplying Respirators

Atmosphere-Supplying Respirators (ASRs) provide clean air from a source separate from the work area and are used in environments too hazardous for APRs. For work at hazardous waste sites, it is recommended to only use ASRs that operate in positive-pressure mode. This ensures that clean air is constantly supplied to the user, reducing the risk of inhaling hazardous substances.

ASRs fall into three categories:

- **Self-Contained Breathing Apparatuses** (SCBAs) consist of a facepiece connected to an air source carried by the wearer.
- **Supplied-Air Respirators** (SARs) deliver air from a distant source through an air-line hose. SARs are not suitable for entry into immediately dangerous to life and health (IDLH) atmospheres, unless equipped with an escape self-contained breathing apparatus (SCBA). The air source for SARs can be compressed air cylinders or a compressor that purifies and delivers ambient air to the facepiece. SARs suitable for use with compressed air are classified as "Type C" Supplied-Air Respirators. To ensure safety, all SAR couplings must be incompatible with the outlets of other gas systems on the site.
- **Combination SCBA/SAR systems** combine the features of a SCBA with a SAR using a regulator. It allows the user to switch between SCBA and SAR modes manually or automatically, which provides flexibility for entry and exit from contaminated areas as well as extended work periods while connected to the airline This system is suitable for situations where workers need to travel a significant distance within a hot zone and remain there for prolonged work periods, such as drum sampling.

It's important to note that the combination SCBA/SAR should not be confused with a SAR with escape provisions. The primary difference is the airtime provided by the SCBA. The combination system offers up to 60 minutes of self-contained air, while an escape SCBA provides a much shorter duration, typically around 5 minutes. NIOSH certification allows up to 20 percent of the available airtime to be used during entry for the combination unit, whereas the SAR with escape provision is certified for escape purposes only.

3.2.4 APRs versus ASRs

Let's examine the relative advantages and disadvantages of APRs and ASRs.

Air-Purifying Respirators

- **Advantages:**
  - APRs provide effective respiratory protection with a weight generally under 2 pounds (except for Powered Air-Purifying Respirators [PAPRs]).
  - PAPRs enhance mobility and are lighter in weight compared to SCBAs.
- **Disadvantages**:
  - APRs provide limited duration of protection and require monitoring of contaminant and oxygen levels.
  - PAPRs cannot be used in IDLH or oxygen-deficient atmospheres.
  - PAPRs only protect against specific chemicals and up to specific concentrations.

Self-Contained Breathing Apparatuses

- **Advantages:**
  - SCBAs provide the highest level of protection against airborne contaminants and oxygen deficiency, especially in strenuous work conditions.
  - They offer protection against most types and levels of airborne contaminants.
- **Disadvantages:**
  - SCBAs are bulky and heavy, weighing up to 35 pounds, which can increase the likelihood of heat stress and restrict movement in confined spaces.
  - The duration of the air supply is limited, determined by the amount of air carried and its consumption rate.

Supplied-Air Respirators

- **Advantages:**
  - SARs enable longer work periods compared to SCBAs.
  - They are less bulky and lighter than SCBAs, weighing less than 5 pounds (or around 15 pounds with escape SCBA protection).
  - SARs protect against most airborne contaminants.
- **Disadvantages:**
  - SARs are not approved for use in IDLH atmospheres or oxygen-deficient atmospheres, unless equipped with an emergency egress unit such as an escape-only SCBA.
  - The airline restricts worker mobility and requires retracing steps when leaving the area.
  - The airline is susceptible to puncture, chemical permeation, damage from heavy equipment, and obstruction from failing drums. Hazards should be removed whenever possible.

- Airlines should be kept as short as possible, with a maximum approved length of 300 feet (91 meters). Other workers and vehicles should be kept away from the airline.
- The use of air compressors as the air source for SARs at hazardous waste sites is limited due to concerns about the quality of ambient air. OSHA standards impose restrictions on onsite compressor use.

Considerations:

When considering the use of respirators, the following questions should be asked:

- Is the atmosphere IDLH or likely to become IDLH? If yes, a combination SAR/SCBA or SCBA alone should be used.
- Will the air hose significantly restrict worker mobility? If yes, the work task should be modified or alternative respiratory protection should be considered.
- Is there a risk of airline damage, obstruction, or chemical permeation? If yes, the hazard should be addressed, or other respiratory protection should be used.
- If a compressor is the air source, is there a possibility of airborne contaminants entering the air system? If yes, efficient filters and/or sorbents should be available to remove those contaminants. Otherwise, cylinders should be used as the air source, or alternative respiratory protection should be used.
- Can other workers and vehicles be kept away from the area to avoid interference with the airline? If no, alternative respiratory protection should be considered.

3.2.5 Regulations and Approvals

Federal regulations mandate the use of respirators that have undergone testing and approval by NIOSH and the Mine Safety and Health Administration (MSHA). Approved respiratory equipment will have clear approval numbers displayed. However, it's important to note that not all respiratory equipment on the market is approved. NIOSH periodically publishes a list called the Certified Equipment List, which includes all approved respirators and respiratory components.

Note that approval testing for respirators is conducted under specific conditions, which means that the protection provided by a respirator can be compromised in certain situations. This includes situations where a worker has a high breathing rate, the ambient temperature is extremely high or low, or the worker has a poor facepiece-to-face seal. At high breathing rates, positive-pressure respirators may not maintain positive pressure during peak inhalation and exhalation valves may leak. Excessive sweat in high temperatures can break the facepiece seal, while low temperatures can cause ice-clogging of the exhalation valve and regulator. Additionally, a poor facepiece seal due to factors like facial hair, missing teeth, scars, or improper fit testing can result in the penetration of air contaminants.

Assigned Protection Factor
The level of protection provided by a respirator is indicated by its Assigned Protection Factor (APF). The APF is determined experimentally by measuring the seal of the facepiece and leakage from the exhalation valve. It represents the relative difference in substance concentrations outside and inside the facepiece maintained by the respirator. For example, a full-facepiece APR has an APF of 50, meaning workers wearing these respirators should be protected in atmospheres with chemical concentrations up to 50 times higher than the appropriate limits. More information on APFs can be found in OSHA Publication 3352, Assigned Protection Factors.

Exposure Limits
When the identity and concentration of chemicals in the air are known at a worksite, a respirator should be selected with a sufficiently high protection factor to ensure the wearer is not exposed to chemicals above the applicable limits. These limits include the American Conference of Governmental Industrial Hygienists' Threshold Limit Values (TLVs), OSHA's Permissible Exposure Limits (PELs), and NIOSH's Recommended Exposure Limits (RELs). These limits are designed to protect workers who may be exposed to chemicals consistently throughout their working life. OSHA's PELs are legally enforceable exposure limits and represent the minimum level of protection that must be met.

Section 3.3 Selection of Protective Clothing and Accessories

3.3.1 Full-Body Protection

Different types of protective clothing serve specific purposes, although not all are designed to protect against chemical exposure. Here are descriptions of various types of full-body protection:

- Fully encapsulating suits: One-piece garments that provide protection against splashes, dust, gases, and vapors. They can cause heat stress and limit mobility, vision, and communication.
- Non-encapsulating suits: Consists of jackets, hoods, pants, or coveralls. They protect against splashes and dust, but not gases and vapors. They may contribute to heat stress and do not cover the head or neck fully.
- Aprons, leggings, and sleeve protectors: Additional protective coverings worn over non-encapsulating suits to offer splash protection for the chest, forearms, and legs. Used when there is a low probability of total body contact with contaminants.
- Firefighters' protective clothing: Includes gloves, helmet, coat, pants, and boots. Designed to protect against heat and some particles but not gases, vapors, or chemical permeation.
- Proximity garments (approach suit): Worn over other protective clothing, such as chemical-protective clothing or flame-retardant coveralls. Provides brief protection

against radiant heat and can be customized to protect against certain chemical contaminants.

- Blast and fragmentation suits: Vests, clothing, blankets, and carriers designed to provide some protection against small detonations. They do not offer hearing protection.
- Radiation-contamination protective suits: Various types of clothing designed to prevent radioactive particle contamination of the body. Protect against alpha and beta particles but not gamma radiation. Consult an experienced radiation expert if radiation is detected.
- Flame/fire retardant coveralls: Worn as undergarments to protect against flash fires. They may add bulk, exacerbate heat stress, and restrict mobility.
- Flotation gear: Life jackets or work vests worn underneath chemical protective clothing to prevent degradation by chemicals. Adds buoyancy in water but adds bulk and restricts mobility. Must meet USCG standards.
- Cooling garments: Designed to remove excess heat generated by worker activity, equipment, or the environment. Various methods are used, such as circulating cool air, ice packets, or chilled water circulation. Each method has its own advantages and considerations.

3.3.2 Head Protection

- Safety helmet (hard hat): Made of hard plastic or rubber, it protects the top and sides of the head from blows. Must meet OSHA 1910.135 requirements.
- Helmet liner: Provides insulation against cold but does not protect against chemical splashes.
- Hood: Worn with a helmet, it protects against chemical splashes, particulates, and rain.
- Protective hair covering: Prevents chemical contamination of hair and entanglement in machinery or equipment. Important for workers with long hair.

Hard Hat Types (from American National Standards Institute [ANSI]):

- Type 1 Hard Hats: Designed to protect from falling objects.
- Type 2 Hard Hats: Provide protection from falling objects and lateral impact.

ANSI Classes of Hard Hats:

- Class G (General Hard Hats): Commonly used for impact protection and provide electrical protection up to 2200 volts.
- Class E (Electrical Hard Hats): Approved for use in areas with potential electrical hazards, offering dielectric protection up to 20,000 volts.
- Class C (Conductive Hard Hats): Provide impact protection but no electrical protection.

3.3.3 Eye, Face, and Ear Protection

- Face shield: Offers full-face coverage and protects against chemical splashes but not projectiles.

- Splash hood: Protects against chemical splashes but not projectiles.
- Safety glasses: Protect eyes from large particles and projectiles. Special protective lenses should be used when lasers are present.
- Goggles: Depending on construction, they protect against vaporized chemicals, splashes, large particles, and projectiles.
- Sweat bands: Prevent sweat-induced eye irritation and vision impairment.
- Ear plugs and muffs: Protect against physiological damage and psychological disturbance but may interfere with communication.
- Headphones: Provide hearing protection and communication, which is beneficial in emergency conditions.

3.3.4 Hand, Arm, and Foot Protection

- Gloves and sleeves: Integral, attached, or separate from other protective clothing to protect against chemical contact. Jacket cuffs should overlap glove cuffs and gloves should be taped to sleeves for additional protection.
- Overgloves: Offer supplemental protection and prevent damage to undergarments.
- Disposable gloves: Reduce decontamination needs.
- Safety boots: Constructed with chemical-resistant materials to protect against chemical exposure. Some boots may include steel components for compression, crushing, and puncture protection. Nonconductive boots protect against electrical hazards.
- Disposable shoes or boot covers: Slip over footwear to protect boots from contamination and contact with chemicals.

3.3.5 General Protection Devices

- Knife: A tool for various tasks. Allows for emergency escape from a fully encapsulating suit. Should be used with caution to avoid damaging the suit.
- Flashlight or lantern: Enhances visibility in buildings and enclosed spaces. Must be intrinsically safe or approved for hazardous environments.
- Personal dosimeter: Measures exposure to ionizing radiation and certain chemicals. Placed inside the fully encapsulating suit to estimate body exposure.
- Personal locator beacon: Used to locate a victim through sound, radio, or light signals.
- Two-way radio: Enables communication between field workers and support personnel.
- Safety belts, harnesses, and lifelines: Facilitate work in elevated areas or confined spaces and allow for carrying tools and equipment. Must be constructed with spark-free hardware and chemical-resistant materials.

Section 3.4 PPE Ensemble Selection, Use, and Inspection

3.4.1 Factors to Consider for Selection

Establishing the anticipated duration of a work mission is crucial before workers begin their tasks in PPE ensembles. Several factors can limit the mission length and should be taken into consideration:

- **Air Supply Consumption**: The duration of the air supply in SCBA-assisted work activities should be considered. The designated operating time of an SCBA is indicated on the breathing apparatus, but factors such as work rate, fitness level, body size, and breathing patterns can affect the actual operating time.
- **Suit/Ensemble Permeation and Penetration**: The potential permeation or penetration of chemical contaminants into the protective clothing ensemble should be a concern. Factors such as suit valve leakage, suit fastener leakage, and exhalation valve leakage can affect the duration of protection provided by the ensemble.
- **Ambient Temperature**: Ambient temperature plays a significant role in work mission duration, as it affects both the worker and the protective integrity of the ensemble. Heat stress is a concern, and extreme temperatures can impact valve operation, suit materials, fasteners, breakthrough time of chemicals, and concentration of airborne contaminants.
- **Coolant Supply**: Under warm or strenuous conditions, providing adequate coolant is necessary to maintain a comfortable body temperature and reduce the risk of heat stress. The duration of the coolant supply directly affects mission duration.

Personal factors should also be considered:

- **Facial Hair**: Facial hair that interferes with the respirator fit should be prohibited, and long hair must be properly contained within protective hair coverings.
- **Eyeglasses**: Conventional temple pieces on eyeglasses can interfere with the seal of a full-face respirator. Workers requiring vision correction should use a spectacle kit installed in the face masks.
- **Corrective Lenses**: Corrective lenses should be fitted by qualified individuals to ensure good vision, comfort, and a proper seal. Wearing contact lenses with a respirator in a contaminated atmosphere is prohibited.
- **Gum and Tobacco**: Chewing gum and tobacco should be prohibited during respirator use as they may compromise the fit and lead to ingestion of contaminants.

3.4.2 How to Use PPE Ensembles

To don an ensemble properly, a procedure should be established and practiced periodically. The following is a sample procedure for donning a fully encapsulating suit/SCBA ensemble:

1. Inspect the clothing and respiratory equipment.
2. Adjust the hard hat or headpiece if worn.

3. Open the back closure used to change the air tank (if applicable).
4. Step into the legs of the suit and gather it around the waist.
5. Put on chemical-resistant safety boots over the suit feet and tape the leg cuff over the tops of the boots.
6. Put on the air tanks and SCBA harness assembly, don the facepiece, and adjust it securely.
7. Perform negative and positive respirator facepiece seal tests.
8. Put on inner gloves and secure them to the suit sleeves (if applicable).
9. Put the suit sleeves over the arms as an assistant helps pull the suit over the SCBA, ensuring unrestricted motion.
10. Put on a hard hat if needed.
11. Raise the hood overhead carefully, adjusting it for comfort without disrupting the face seal of the SCBA mask.
12. Secure the suit by closing all fasteners, leaving adequate room to connect the breathing hose. Secure all belts and adjustable bands.
13. Connect the breathing hose while opening the main valve.
14. Have an assistant ensure proper breathing and make the final closure of the suit.
15. Have an assistant check all closures and observe the wearer for comfort and proper equipment functioning.

Using a moderate amount of powder during suit donning can help prevent chafing and increase comfort. Powder can also reduce rubber binding.

Once the protective equipment has been donned, it is essential for the wearer to understand its operation and limitations. Proper fit should be evaluated to ensure:

- The clothing is not too small, as it can restrict movement and increase the risk of tearing the material and causing worker fatigue.
- The clothing is not too large, as it can increase the possibility of snagging and compromise worker dexterity and coordination. In such cases, the worker should be recalled and provided with better-fitting clothing.

During equipment use, workers should be encouraged to report any problems or difficulties they encounter to their supervisors. These issues may include:

- Degradation of the protective ensemble
- Perception of odors
- Skin irritation
- Unusual residues on PPE
- Discomfort
- Respiratory resistance
- Fatigue due to respirator use
- Interference with vision or communication
- Restriction of movement

- Personal responses such as rapid pulse, nausea, and chest pain

If SARs are being used, all hazards that may compromise the airline's integrity should be removed from the working area. Airlines should be kept as short as possible, and access to the area should be restricted to other workers and vehicles.

3.4.3 Post Use of an Ensemble

Procedures for removing fully encapsulating suit/SCBA ensembles at the worksite should be established and followed to prevent contaminant migration and transfer. The following are sample doffing procedures:

- If sufficient air supply allows decontamination before removal:
    1. Remove extraneous or disposable clothing, boot covers, outer gloves, and tape.
    2. Have an assistant loosen and remove the wearer's safety shoes or boots.
    3. Have an assistant open the suit completely and lift the hood over the wearer's head, resting it on top of the SCBA tank.
    4. Remove one arm at a time from the suit. Once both arms are free, have the assistant lift the suit up and away from the SCBA backpack, avoiding contact between the suit's outside surface and the wearer's body. Lay the suit out flat behind the wearer. Leave internal gloves on, if applicable.
    5. If sitting is possible, remove both legs from the suit.
    6. Follow the procedure for doffing the SCBA.
    7. After removing the suit, roll off the internal gloves inside out.
    8. Remove internal clothing and thoroughly cleanse the body.
- If the low-pressure warning alarm has sounded, indicating approximately 5 minutes of air remains:
    1. Remove disposable clothing.
    2. Quickly scrub and hose off, paying particular attention to the entrance/exit zipper area.
    3. Open the zipper enough to access the regulator and breathing hose.
    4. Immediately attach an appropriate canister to the breathing hose (pre-determined type and fittings). Note that while this provides some protection against any remaining contamination, it voids the unit's certification.

Clothing Reuse:

Chemicals that have permeated the clothing during use may not be fully removed during decontamination and can continue to diffuse through the material towards the inside surface. This presents a hazard to the next person who uses the clothing. Therefore, clothing should be checked inside and out for discoloration or other signs of contamination.

For fully encapsulating suits, which are often subject to reuse due to their cost, careful consideration must be given to potential hazards. Reuse decisions should take into account the known factors of permeation rates and the toxicity of the contaminants. It is not advisable to reuse Chemical Protective Clothing contaminated with toxic chemicals unless extreme care is taken to ensure proper decontamination without degrading the material.

Section 3.5 Selecting Chemical Protective Clothing

Chemical Protective Clothing (CPC) is available in various materials that offer different levels of protection against chemicals. The choice of clothing material depends on the specific chemicals present and the task at hand. Ideally, the selected material should resist permeation, degradation, and penetration.

The selection of CPC is a complex process and should be conducted by trained personnel with experience in the field. The choice of clothing is determined during site characterization and depends on the type and physical state of the contaminants. It is recommended to inspect representative garments before purchasing and discuss their performance with knowledgeable individuals. Ultimately, it is the employer's responsibility to ensure that the personal protective clothing, including CPC, is adequate and safely designed. CPC should ideally be used only after other options to control skin exposures are investigated. If CPC is deemed necessary, it should be used by workers with an appropriate level of understanding of its proper use.

3.5.1 Permeation and Degradation

Permeation and degradation are important factors to consider when selecting CPC. Sources such as the NIOSH Recommendations for Chemical Protective Clothing Database can be used as a starting point for considering which materials might provide resistance to chemical permeation under laboratory testing conditions. It is important to note that no material can protect against all chemicals, and currently available materials are not effective barriers for prolonged chemical exposure.

Permeation rate depends on factors, such as clothing material type and thickness, manufacturing method, chemical concentration, temperature, pressure, humidity, solubility of the chemical, and diffusion coefficient. Breakthrough time refers to the time it takes for a hazardous material to penetrate the CPC material and become detectable on the inside.

When dealing with mixtures, limited permeation data may be available. Mixtures can be more aggressive towards CPC materials compared to individual components. Heat transfer characteristics of CPC should also be considered, especially in hot environments. The "clo" value indicates the thermal insulation capacity of the garment. The larger the clo value, the greater the insulating properties of the garment. A clo of zero indicates no garments are worn.

3.5.2 Other Factors to Consider

Other factors to consider include durability, flexibility, temperature effects, ease of decontamination, compatibility with other equipment, and the duration of use. CPC should withstand physical stress, allow workers to perform their tasks, maintain protective integrity under extreme temperatures, and be compatible with other necessary equipment. The duration of use should be considered to ensure tasks can be completed before breakthrough or significant degradation occurs.

Fire, explosion, heat, and radiation are considered special conditions that require specific protective equipment. Radiation hazards should be addressed by consulting a qualified health physicist.

3.5.3 EPA Levels of Protection

The EPA Levels of Protection (Levels A, B, C, and D) serve as a starting point for assembling PPE ensembles. However, each ensemble should be tailored to the specific situation to provide the most appropriate level of protection.

Level A Protection: Level A is used when the highest level of respiratory, skin, and eye protection is required. It is suitable for chemicals that pose a high risk to the skin or in confined, poorly ventilated areas. Level A equipment includes positive pressure SCBAs, totally encapsulating chemical-protective suits, gloves, boots, and other optional items.

Level B Protection: Level B protection provides the same respiratory protection as Level A but offers less skin protection. It is recommended for situations where a high level of respiratory protection is required but the skin hazard is less severe. Level B equipment includes positive pressure SCBAs or SARs, hooded chemical-resistant clothing, gloves, boots, and other optional items.

Level C Protection: Level C protection offers the same level of skin protection as Level B but provides a lower level of respiratory protection. It is suitable when atmospheric contaminants or direct contact will not adversely affect exposed skin, and specific air contaminants have been identified. Level C equipment includes air purifying respirators, hooded chemical-resistant clothing, gloves, boots, and other optional items.

Level D Protection: Level D protection is sufficient when no respiratory protection and minimal skin protection are required. It is used when work is conducted outside the Exclusion Zone and the atmosphere contains at least 19.5 percent oxygen. Level D equipment includes coveralls, gloves, boots, safety glasses or goggles, hard hat, and other optional items.

3.5.4 Periodic Evaluations of CPC Use

The type of equipment used and the overall level of protection should be reevaluated periodically as more information about the site becomes available and tasks change. Upgrading or downgrading the level of protection should be done with the approval of the Site Safety Officer and Field Team Leader, considering factors such as the presence of dermal hazards, changes in work tasks, and new information indicating a decrease or increase in hazards.

Training in the use of respirators and general PPE is required by OSHA standards. This training serves several important purposes:

1. **Familiarization:** Training allows users to become familiar with the equipment in a non-hazardous setting, building confidence in their ability to use it effectively.
2. **Awareness:** Users are made aware of the limitations and capabilities of the equipment, understanding its proper use and potential risks.
3. **Efficiency**: Training increases the efficiency of operations performed by workers wearing PPE, ensuring that it is used effectively and appropriately.
4. **Cost reduction**: Proper training can help reduce the expenses associated with PPE maintenance by ensuring that equipment is used and maintained correctly.

PPE training should be completed before workers are exposed to hazardous environments and should be repeated at least annually. The training program should cover user responsibilities and include the following topics:

- OSHA requirements related to PPE use
- Proper use and maintenance of selected PPE, including understanding its capabilities and limitations
- Awareness of hazards and the consequences of not using PPE
- Understanding the human factors that can influence PPE performance
- Instruction in inspecting, donning, checking fit, and using PPE correctly
- Individualized respirator fit testing to ensure a proper fit
- Practice using PPE in a non-hazardous environment to gain familiarity
- Evaluating the effectiveness of PPE by wearing it in a test atmosphere
- User responsibilities for decontamination, cleaning, maintenance, and repair of PPE
- Emergency procedures and self-rescue in case of PPE failure
- Importance of the buddy system for added safety
- Understanding the Site Safety Plan and individual responsibilities in emergency situations

It's important to address any discomfort or inconvenience associated with wearing PPE during the training to ensure that users understand the need for PPE and are motivated to use and maintain it properly.

Section 3.6 CPC Inspection, Storage and Maintenance

3.6.1 CPC Inspection

Proper inspection and storage of CPC are crucial for ensuring the reusability of PPE and reducing long-term expenses. An effective CPC inspection program typically includes the following five inspections:

1. Inspection and operational testing of equipment received from the factory or distributor
2. Inspection of equipment as it is issued to workers

3. Inspection after use or training and before maintenance
4. Periodic inspection of stored equipment
5. Periodic inspection when questions arise about the appropriateness of selected equipment or when similar equipment problems occur

Each inspection covers different areas with varying degrees of depth. Manufacturer-provided detailed inspection procedures, where available, can be a helpful resource. The following sample inspection checklists can also serve as aids:

Clothing

Check before use:

- Verify that the clothing material is appropriate for the specific task.
- Visually inspect for imperfect seams, non-uniform coatings, tears, and malfunctioning closures.
- Hold the clothing up to light and check for pinholes.
- Flex the product and observe for cracks or other signs of shelf deterioration.
- If the product has been used before, inspect inside and out for signs of chemical attack, such as discoloration, swelling, and stiffness.

Periodically check during the work task:

- Look for evidence of chemical attack, including discoloration, swelling, stiffening, and softening. Keep in mind that chemical permeation can occur without visible effects.
- Check for closure failure, tears, and punctures.
- Inspect for seam discontinuities.

Gloves

Check before use:

- Pressurize the glove to check for pinholes (either blow into the glove and roll the gauntlet towards the fingers or inflate the glove and hold it under water--no air should escape).

Fully Encapsulating Suits

Check before use:

- Check the operation of pressure relief valves.
- Inspect the fitting of wrists, ankles, and neck.
- Inspect the face shield, if equipped, for cracks, crazing (a network of small cracks), and fogginess.

SCBA

Inspect SCBAs at the following times:

- Before and after each use
- At least monthly when in storage
- Every time they are cleaned

What to check:

- Inspect all connections for tightness.
- Examine material conditions for signs of pliability, deterioration, and distortion.
- Check for the proper setting and operation of regulators and valves.
- Check the operation of the alarm and inspect for cracks, crazing, and fogginess.

SARs

Inspect SARs at the following times:

- Daily when in use
- At least monthly when in storage
- Every time they are cleaned

What to check:

- Inspect all connections for tightness.
- Examine material conditions for signs of pliability, deterioration, and distortion.
- Check for the proper setting and operation of regulators and valves.
- Inspect face shields and lenses for cracks, crazing, and fogginess.
- Inspect airlines before each use for cracks, kinks, cuts, frays, and weak areas.

APRs

Inspect APRs at the following times:

- Before each use to ensure they have been adequately cleaned
- After each use
- During cleaning
- Monthly if in storage for emergency use

What to check:

- Examine material conditions for signs of pliability, deterioration, and distortion.
- Examine cartridges or canisters to ensure they are the proper type for the intended use, the expiration date has not passed, and they have not been opened or used previously
- Check face shields and lenses for cracks, crazing, and fogginess,

3.6.2 CPC Storage and Maintenance

Clothing and respirators must be stored properly to prevent damage or malfunction due to various factors. Follow these guidelines for storage:

Clothing:

- Store potentially contaminated clothing separately from street clothing.
- Keep potentially contaminated clothing in a well-ventilated area with good airflow around each item, if possible.
- Store different types and materials of clothing and gloves separately to prevent issuing the wrong material by mistake.
- Fold or hang protective clothing according to manufacturers' recommendations.

Respirators:

- SCBAs, SARs, and APRs should be dismantled, washed, and disinfected after each use.
- SCBAs should be stored in storage chests provided by the manufacturer.
- APRs should be stored individually in their original cartons or carrying cases, or in heat-sealed or re-sealable plastic bags.

CPC maintenance procedures can vary in technical depth, and certain parts may only be available to authorized individuals or groups trained by the manufacturer. The classification scheme for maintenance is as follows:

- Level 1: User or wearer maintenance, requiring a few common tools or no tools at all
- Level 2: Shop maintenance that can be performed by the employer's maintenance shop
- Level 3: Specialized maintenance that can only be performed by the factory or an authorized repair person