24-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).

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

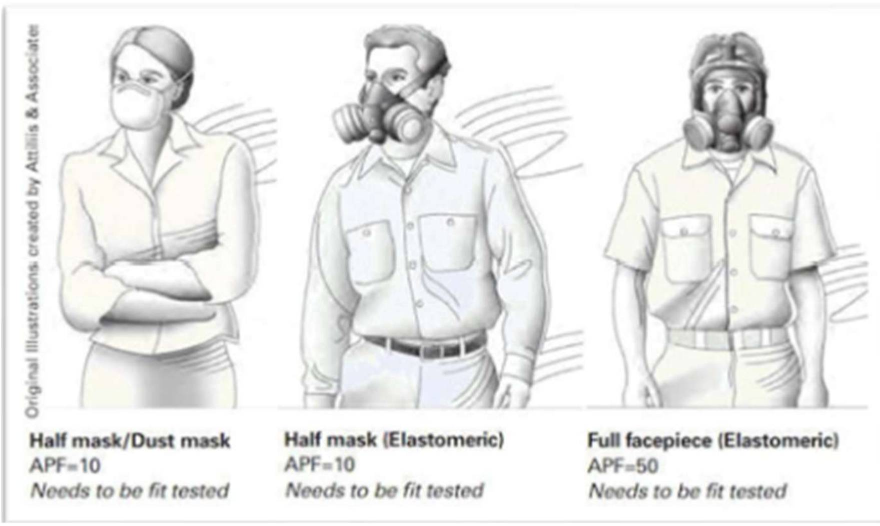
3.2.1 Introduction to Respiratory Protection

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.

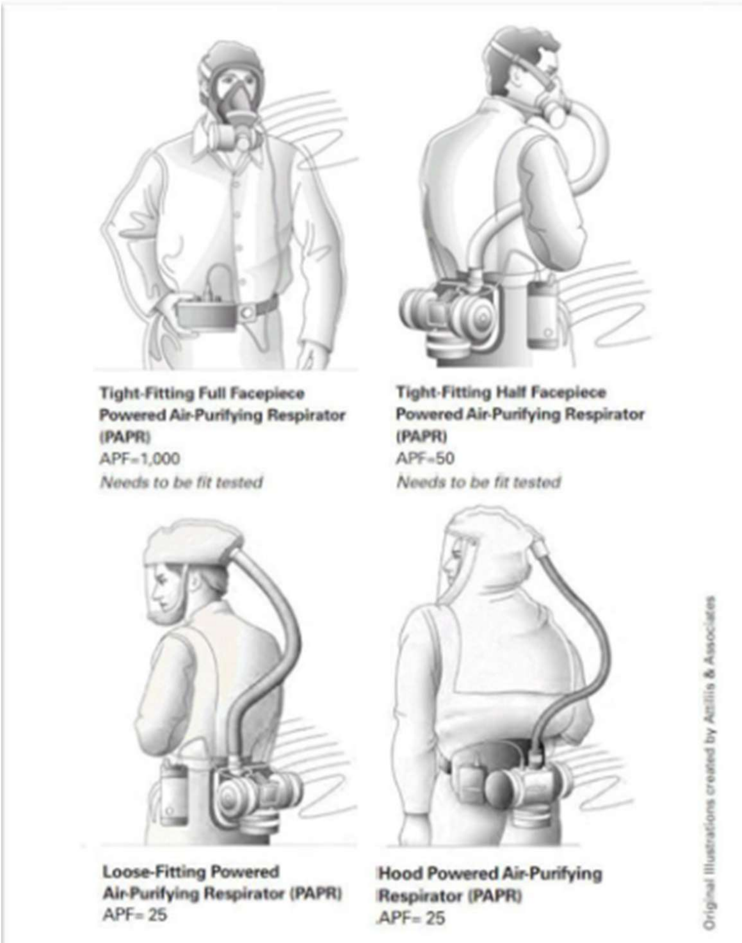
Half masks cover the lower part of the face, extending from below the chin to over the nose. However, it's important to note that half masks do not provide protection for the eyes.



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.

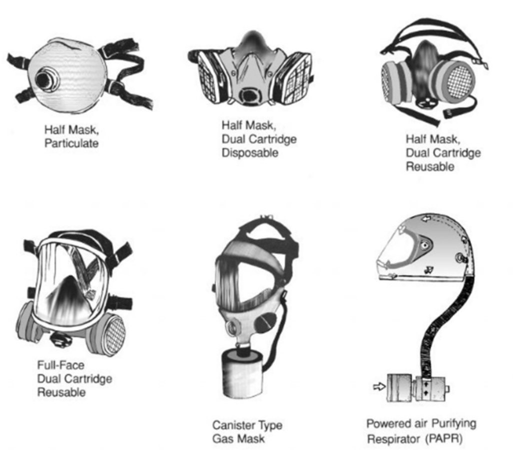
In the following sections, two types of respirators will be discussed: Air-Purifying Respirators and Atmosphere-Supplying Respirators.

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).

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 WHITE with 1/2" GREEN stripe completely around bottom canister WHITE with 1/2" YELLOW stripe completely around bottom canister	Hydrogen Chloride, Sulfur Dioxide, Hydrogen Sulfide Hydrcyanic Acid Vapor Pure Chlorine
BLACK	Organic Vapors (OV)
YELLOW YELLOW with 1/2" BLUE stripe completely around bottom canister	Organic Vapors with Hydrogen Chloride, Sulfur Dioxide, Hydrogen Sulfide, or Hydrogen Fluoride Hydrcyanic Acid and Chloropicrin vapor
GREEN GREEN with 1/2" WHITE stripe completely around bottom canister	Ammonia, or Ammonia and Methylamine 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.

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.

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.

3.2.5 Regulations

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.

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. 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 Selecting Chemical Protective Clothing

3.4.1 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.