PERSONAL PROTECTIVE CLOTHING AND EQUIPMENT

1.0 INTRODUCTION

Vapors, gases, and particulate from hazardous waste sites and emergency response and select field activities, may place field personnel at risk. For this reason, field personnel must wear appropriate personal protective clothing and equipment (PPE). The purpose of PPE is to shield or isolate individuals from the chemical, physical, and biological hazards that may be encountered. Because no one type or combination of protective clothing and equipment is capable of protecting against all hazards, PPE should be used in conjunction with (not in place of) engineering controls and safe work practices. However, PPE is often the primary line of defense in the field because engineering controls are not always feasible.

Learning Objectives

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

- Explain the uses, types, and corresponding characteristics of PPE
- Explain the concepts behind the selection of PPE
- Identify stresses associated with wearing/using PPE
- List levels of protection and appropriate ensembles
- Explain the importance of correct donning/doffing procedures
- Describe how to follow proper inspection, maintenance, and storage procedures.

2.0 TYPES OF PERSONAL PROTECTIVE CLOTHING AND EQUIPMENT

The selection of appropriate protective equipment is based on all of the hazards and risks anticipated or recognized. The following sections discuss various types of personal protective clothing and equipment and list examples for each. Specific information on the EPA Levels of Protection, and the types of PPE required for each level is provided in Section 7.

Under the newly revised OSHA standards (29 CFR 1910.132, .133, .135, and .136), employers are required to assess the workplace to determine what potential hazards are present which require the use of PPE. If PPE is needed, employers are required to:

- Select and have each employee use the appropriate types of PPE
- Communicate selection decisions to each affected employee
- Select PPE that properly fits each affected employee
- Provide training to each employee required to wear PPE.

Each affected employee must demonstrate an understanding of the required training and the ability to use PPE properly before performing work requiring the use of PPE.

2.1 Head Protection

Head protection is required when working in areas (e.g., near drilling rigs, in excavations, at industrial plants) where there is a potential for head injury, either from falling objects or when working near exposed electrical conductors which could contact the head.

The hard hat, a basic piece of safety equipment used in many work operations, must meet ANSI Z89.1-1986 specifications for protection if purchased after July 5, 1994. If purchased before this date, ANSI Z89.1-1969 specifications must be met. ANSI designates the type of hard hats available into four classes based on the work and the hazards that may be encountered.

Class A: Limited voltage resistance for general service
Class B: High voltage resistance
Class C: No voltage protection
Class D: Limited protection for fire fighting

2.2 Eye and Face Protection

During the course of field activities you may be exposed to eye or face hazards such as flying particles, molten metal, liquid chemicals, acids or caustic liquids, chemical gases or vapors, or potentially injurious light radiation. These conditions may warrant the use of eye and face protection.

Safety glasses, goggles, and face shields must meet ANSI Z87.1-1989 specifications if purchased after July 5, 1994. If purchased previously, it must comply with ANSI. Z87.1-1968 specifications. Contact lenses are normally prohibited on site since they can cause many problems (e.g., OSHA prohibits use of contact lenses with respirators per 29 CFR 1910.134). It is best to wear prescription eyeglasses rather than contact lenses for the best overall protection.

Eye protection is available in several styles and is primarily designed for protection against flying particles and splashes. Examples of eye protection include the following:

- Spectacles with impact-resistant lenses
  - Used for protection from flying particles
  - Patterned after conventional eyeglasses but are more substantial in construction
  - "Plano" (nonprescription) varieties
  - Prescription lenses can be ground
  - Fixed or clip-on side shields for side protection
  - Clear, filtered, tinted, plastic or glass lenses
  - Can be a component of full face respirator (e.g., eye glass kit)

- Flexible or cushion-fitting goggles

- Splash goggles
- Protect against fine dust, fumes, liquids, mists, and sprays
- Lenses are mounted in a flexible or rigid frame with a cushioned surface where they contact the face
- Usually ventilated to prevent fogging
- Flexible-fitting goggles which have a frame of nonrigid material, often less protection against impact than cushion-fitting goggles or eyecup goggles

• Eyecup goggles
  - Similar use as flexible/cushion-fitting goggles
  - Each eyecup has a lens retainer bearing evenly on the lens with enough pressure to retain fragments if a lens breaks
  - Lenses can be renewed/replaced
  - Some goggles will fit over corrective spectacles

• Faceshields
  - Not recommended for impact protection, welding, cutting, etc.
  - Designed for protection from flying particles, sprays and splashes of liquids
  - Can be used for anti-glare depending on material of construction
  - Can be used with safety glasses and splash goggles if a major impact/splash hazard exists
  - Can be a separate unit or attached to a hard hat

• Full-face respirators (Air purifying or supplied air)
  - Provide both impact and splash protection
  - Can be equipped with corrective lenses.

Safety glasses and/or splash goggles can be used when a half-face respirator is used with or without a face shield.

2.3 Foot Protection

Protective footwear is required when working in areas where there is a danger of foot injuries due to falling and rolling objects, or where feet are exposed to sharp objects, or electrical hazards.

Footwear worn during field activities (including leather work boots and chemically-resistant boots) must meet the specifications of ANSI Z41.1-1991 if purchased after July 5, 1994, and ANSI Z41.1-1967 if purchased before this date. The materials used to make the boots are not subject to any standards. For impact, safety footwear has a metal/plastic cap or box built into the toe. Steel shanks or insole inserts minimize the risk of puncture-related (through the bottom) foot injuries. Protection against liquid hazardous chemicals requires a boot made of neoprene, PVC, butyl rubber, or some other elastomer.

Boots are generally available in the following two styles:

- Pullover
  - Disposable overbooties (e.g., Tyvek, latex, PVC)
  - Rubbers and overboots (e.g., utility worker's legging boots)
  - Assist in keeping underboots from getting contaminated
  - Can be worn over a traditional leather safety shoe or boot or over an elastomer (chemically-resistant) boot
  - Most are disposable and inexpensive

- Shoe-boot
  - Leather and chemically-resistant varieties
  - Normally are not considered disposable; if contaminated must be properly disposed
  - Steel toe/steel shank
  - Chemically-resistant boots can be decontaminated to a degree
  - Cold-weather boots available
  - Range from inexpensive to expensive.

2.4 Hearing Protection

Earplugs or earmuffs must be issued when noise may be above established action levels, such as around heavy equipment and when using noisy tools.

Each person's auditory canal is a different size and shape. Thus, earplugs can be custom fitted and made for the individual. Since your ear canal can change shape/size at different times, fitting this type of plug can be difficult. The major drawbacks of this type of plug are the expense and the requirement to keep plugs clean at all times and the tendency of the plugs to shrink over a period of time. The following are examples of hearing protection devices:

- Preformed plugs: These plugs come in general sizes (small, medium, and large) and do not fit as well as individualized plugs. Preformed plugs can be disposable or nondisposable, and must be cleaned before each reuse to prevent ear infections. Shapes include cones, "Christmas trees," flanged, etc. Many come with a cord.

- Disposable Expanding Foam Type: This type of earplug offers the advantages expanding to fit all sizes of ears, being inexpensive, and being disposable. Disposable ear plugs prevents ear infection. Some of these foam plugs are also corded.

- Ear Muffs: When worn properly ear muffs can provide good protection. However they are relatively expensive, tend to be warm, can be difficult to use when wearing head and respiratory protection devices, and must be cleaned between uses.

Hearing protection devices are typically given a Noise Reduction Rating (NRR) per EPA testing guidelines. This rating is used as a guide to estimate how much noise (dB) the protective device will reduce when properly worn. For example, a protection device with

an NRR 30 will theoretically make a noise of 90 dB sound like 60 dB to the ear (it reduces the noise by 30 dB if 90 db is measured on the c-weighted scale).

Effectiveness of protective devices can be greatly reduced if they allow vibrations to pass around or through the device. If the protector itself vibrates, or if bone or tissue around the protector is allowed to vibrate, the device is ineffective. To prevent these problems, the hearing devices must be made of imperforate material (material which does not allow vibrations to pass through easily). It must provide a good acoustical seal and it must minimize vibrations. When wearing ear muffs, the fit must not be obstructed by long hair, glasses, or any device or piece of clothing, such as a hat or hood.

Review "Occupational Noise" for additional information.

2.5 Hand Protection

Hand protection is required when there is a potential for exposure to hazards such as skin absorption of harmful substances, severe cuts or lacerations, severe abrasions, puncture, chemical burns, thermal burns, and harmful temperature extremes.

The hands are as susceptible to contamination as the feet. Gloves must resist puncturing and tearing as well as provide the necessary chemical resistance. Heavy leather gloves may be worn over chemical protective gloves when doing physical work with materials which are abrasive or sharp. If they become contaminated, they must be discarded because leather is virtually impossible to decontaminate. The specific type of contaminant or class of contaminants must be determined in order to select the appropriate chemically-resistant gloves.

2.6 Skin and Body Protection

Skin and body protection should be selected with a type of hazard in mind (e.g., chemical, thermal, mechanical, radiation). No one suit material will provide appropriate protection in all situations. Each case must be evaluated separately to determine the hazards and appropriate level of protection.

A wide variety of protective garments are available, including:

- Fully encapsulating suit: Use under extremely hazardous or unknown conditions
- Splash suit: Use when chemical splashes or contact are anticipated
- Aprons, leggings, and sleeve protectors: Provide area-specific splash protection
- Firefighter's protective clothing (turnout gear): Provides a degree of fire protection
- Proximity garment: Provides a higher level of fire protection
- Blast and fragmentation suit: Provides some protection from explosives
- Flame retardant coveralls: Provide some fire and heat protection
- Flotation gear: Necessary when working on and/or near water
- Cooling garments: Provide some relief when hot environments are encountered.

When selecting and using protective clothing, remember that the materials are usually not intended for prolonged contact with concentrated chemicals and extra replacement clothing may be required to complete the work. Protective clothing should also be discarded and replaced if it cannot be decontaminated.

Clothing materials should be selected for resistance to degradation from the chemicals to which they will be exposed and for appropriate resistance to penetration and permeation.

3.0 CLASSIFICATION OF CHEMICAL PROTECTIVE CLOTHING

Chemical protective clothing can be classified by style, protective material from which the fabric is made, and whether the clothing is single use or reusable.

3.1 Styles

The types of styles of protective suits are:

- Fully encapsulating suit: The garment completely encloses the wearer (gas-tight or nongas tight). The protection they provide against a specific chemical depends on the material from which they are constructed.

- Nonencapsulating suit: Does not have a facepiece as an integral part of the suit. Splash suits, as they are commonly referred to, are either a one-piece "coverall" or a two-piece "pants and coat." They may be a potential substitute for a fully encapsulating suit if the concentration of airborne contamination is low and the hazardous material is not extremely toxic to the skin.

3.2 Types of Protective Materials

All materials fall into the following two general categories:

- Elastomers are polymeric (plastic-like) materials that, after being stretched, return to approximately their original shape. Elastomers may be supported (layered on cloth-like materials) or unsupported (e.g., neoprene, polyvinyl chloride, teflon).

- Nonelastomers are materials that do not have the quality of stretchability (e.g., Tyvek™ and Tyvek™ coated fabrics, such as polyethylene and Saranex).

3.3 Intended Use

Whether a garment is considered single-use or reusable depends primarily on issues such as:

- Cost
- Ease of decontamination.

4.0 PERFORMANCE REQUIREMENTS

A number of performance requirements must be considered in selecting the appropriate protective material. Their relative importance is determined by the particular work activity and site-specific conditions.

4.1 Chemical Resistance

Chemical resistance refers to the ability of a material to withstand chemical and physical change. This is the most important performance requirement. The material must maintain its structural integrity and protective qualities upon contact with a hazardous substance. Chemical resistance is determined by the penetration, degradation, and permeation of the material or garment.

4.1.1 Penetration

Penetration is the transport of chemicals through openings in a garment. A chemical may penetrate due to design or garment imperfections. Stitched seams, button holes, pinholes, zippers, and woven fabrics can provide a route for the chemical to penetrate the garment. Rips, tears, punctures, or abrasions to the garment also allow penetration. A well designed and constructed garment prevents chemical penetration with self-sealing zippers, seams overlayed with tape, storm-flap closures, and nonwoven fabrics.

4.1.2 Degradation

Degradation is the chemical action involving the molecular breakdown of the material due to chemical contact. Degradation is evidenced by physical changes to the material which may cause the material to shrink or swell, become brittle or soft, or completely change its chemical properties. Other changes may be a slight discoloration, rough or gummy surface, or cracks in the material.

4.1.3 Permeation

Permeation is a chemical action involving the movement of chemicals, on a molecular level, through intact material. Permeation is a process which involves the absorption of the chemical on the outside surface, diffusion through, and deposition of the chemical on the inside surface of the protective material.

The permeation rate is the quantity of chemical that will move through an area of protective material in a given time. Several factors influence the rate of permeation including the type of material and thickness. Other important factors are:

- Chemical concentration: More/less concentration can increase/decrease permeation.
- Contact time: More contact time increases permeation.

- Temperature: Higher temperatures can increase permeation.
- Material grade: Grades of material vary greatly from manufacturers.
- Humidity: Higher humidity can increase permeation.
- Solubility of the material in the chemical: Permeation varies.

Another measure of permeation is breakthrough time, which is the elapsed time between initial contact of a chemical with the outside surface and detection at the inside surface of the material.

4.2 Durability

A material's durability, or inherent strength, is determined by its ability to withstand wear, to resist punctures, abrasions, and tears.

4.3 Flexibility

Flexibility refers to the ability to bend. Flexibility is extremely important both for glove and suit materials because it directly impacts the worker's mobility, dexterity, and agility.

4.4 Temperature Resistance

The ability of a material to maintain its chemical resistance during temperature extremes (especially heat) and to remain flexible in cold weather is termed its temperature resistance. A general characteristic of most materials is that higher temperatures tend to reduce their chemical resistance and lower temperatures tend to reduce their flexibility.

4.5 Service/Shelf Life

Service/shelf life refers to the ability of a material to resist aging and deterioration. Factors such as chemicals, extreme temperatures, moisture, ultraviolet light, oxidizing agents, etc. decrease a material's service life. Storage away from and proper care against these conditions helps prevent aging and extends the life of the suit.

4.6 Cleanability

Cleanability refers to a measure of the ability of a material to release the contact substance, refers to the ability to effectively decontaminate protective materials. The majority of suit materials are being constructed of disposable materials that do not require extensive cleaning prior to disposal.

4.7 Design

Design refers to the construction of the suit, including the general type and specific features. A variety of suit styles and features are manufactured, including:

- Fully encapsulating or nonencapsulating: Give full body covering; either gas tight or nongas tight
- One-, two-, or three-piece suits: Splash protection or general duty garments
- Hoods, facepieces, gloves, and boots (attached or unattached): Provide protection to extremities
- Location of zipper, buttons, storm flaps, and seams (front, side, and back): Should be located and designed to minimize or eliminate penetration of substances
- Pockets, cloth collars, and velcro straps: Not recommended because they can "collect" contamination
- Exhalation valves or ventilation ports: Must be located "away" from potential entry by liquid contaminants
- Ease of compatibility with wearing respiratory protection: Respirators and garments used must be "workable."

4.8 Size

Size relates to the physical dimensions or proportions of clothing. Size is directly related to comfort and affects the number of unnecessary physical accidents. Nonfitting clothing limits a worker's mobility, dexterity, and concentration.

4.9 Color

Brightly colored suit material makes it easier to maintain visual contact of personnel (high visibility). Suits of darker colors, such as black and green, absorb radiant heat from external sources and transfer it to the worker thus increasing heat-related problems.

4.10 Cost

The cost of chemical protective clothing varies considerably. Cost will often play a role in the selection and frequency of use. In some situations, less expensive, single-use garments are more appropriate and as safe as more costly clothing. Other situations require high quality, costly clothing which may have to be discarded after limited use. Never let cost interfere with selecting proper protective clothing.

5.0 SELECTING CHEMICAL PROTECTIVE CLOTHING

Selecting the most effective chemical protective clothing is easier when the chemical from which protection is necessary is known. Selection becomes more difficult when:

- The presence of chemicals is unknown
- Multiple chemicals (known or unknown) are involved
- Hazardous waste or an unidentified substance is present.

The process of selecting chemical protective clothing consists of the following steps:

- Deciding that the worker must be in an environment where they could be exposed, the type of work to be performed, and the amount of time to be spent in the work area
- Identifying the chemical(s) involved and determining physical, chemical, and toxicological properties
- Deciding whether the substance is a skin hazard at the concentrations known or expected
- Selecting protective material which provides the least permeation, penetration, and degradation for the longest period of time
- Determining whether a fully encapsulating or non-encapsulating suit is required.

5.1 Types of Hazardous Material or Hazardous Waste

The predominant physical, chemical, or toxic property of the material dictates the type and degree of protection required. For example, protection against a corrosive compound is different than that for a compound which releases a highly toxic vapor.

5.2 Type of Work To Be Performed and Location

Different levels of protection may be selected and various types of chemical-resistant clothing may be worn for field operations. This selection should be based not only on measured air concentrations, but also on the job function and the reason for being in the hazardous area.

5.3 Amount of Time

The amount of time the worker will be wearing the protective clothing is another important aspect, because of breakthrough times and permeation rates. Several factors may limit the mission length, such as air supply, equipment effectiveness, temperature, and coolant supply.

5.4 Concentration of Material

The higher the concentration of material, the higher the risk of harm. Generally, a higher level of protection will be needed as the concentration increases. For instance, as concentration increases, the limits for air-purifying respirators may be exceeded thus requiring an upgrade to a Level A or Level B to provide the appropriate respiratory protection.

5.5 Known Skin Hazard

If the material is a known skin hazard, the potential for contact with the material and the probability of direct exposure to the skin unprotected by Level B or C chemical-resistant clothing must be considered. MSDSs, the ACGIH TLV Booklet and other references can be consulted to identify materials which present skin hazards.

5.6 Unknown Hazards

Until the toxic hazards can be identified and personnel safety measures are commensurate with the hazards instituted, preliminary measures will have to be based on experience, judgement, and sound professional knowledge. General EPA policy states that entry into unknown, unconfined environments with no visible contaminants (e.g., acid, vapor clouds) should be made with no less than Level B protection.

5.7 Appropriate Protective Materials

After determining the type of protective garment to be worn, the next step is to select the protective material from which it should be made. Vendors or manufacturers of material that make chemical protective materials often supply information concerning their product's chemical resistance and make recommendations about what material is appropriate for protection against certain chemicals. The number of chemicals their product is tested against may be limited; they can not test against all existing chemicals or potential mixtures. Permeation is the primary selection criteria. The best protective material against a specific chemical is one with a very low permeation rate (if any) and a long breakthrough time, and is constructed free of design imperfections.

Appendix A contains a table of general physical characteristics and corresponding ratings for select materials.

6.0 STRESSES

Wearing chemical protective clothing can cause problems including heat stress, difficulty in communicating, decreased vision, dexterity, and mobility, and fatigue.

To minimize the adverse effects of physical stress, workers wearing protective clothing must alter their normal work regimen. A medical surveillance program including baseline physicals and routine medical monitoring should be instituted. Personnel must adjust to stressful environmental factors by varying work and rest periods as needed. Projects should be scheduled for cooler periods of the day whenever possible. In addition, the intake of fluids must be maintained at levels to prevent dehydration and body electrolytes must be replaced throughout the day.

6.1 Heat

The major problem associated with wearing chemical protective clothing is heat stress. Protective clothing interferes with the body's ability to cool itself. Clothing that provides a barrier against chemicals contacting the skin can also prevent the efficient dissipation of body heat. Evaporation, the body's primary cooling mechanism, is reduced since ambient air is not in contact with the skin's surface. Other heat exchange mechanisms such as convection and radiation are also impeded. Additional heat strain is placed on the body as it attempts to maintain heat balance. This added stress can result in health problems

ranging from transient heat fatigue to serious illness or death. For more information on heat stress, refer to "Heat and Cold Stress."

6.2 Communication

Communication is another area which is adversely affected by wearing protective clothing. Hearing is impaired by fully encapsulating suits or nonencapsulating suits worn with hoods or respirators. Voices are muffled and difficult to understand. Because communication is limited while wearing protective clothing, it is generally a good idea to establish hand signals or purchase special communication systems (e.g., link-up respirators and two-way radios, or voice amplifiers).

6.3 Vision

Wearing protective clothing also interferes with vision. Fully encapsulating suits, as well as nonencapsulating suits worn with hoods or respirators, decrease the line of vision and can result in "tunnel vision." Peripheral vision is also greatly decreased when using PPE.

6.4 Dexterity

Dexterity is limited by chemical protective suits. Hand/finger dexterity is the most severely affected. Two pairs of gloves (inner and outer) are usually worn, which makes completing hand/finger tasks more difficult and time consuming.

6.5 Mobility

Depending on the size of the individual and the type of protective clothing worn, mobility can be greatly reduced. Certain protective suits are heavy and cumbersome. Decreased mobility, in combination with reduced vision and increased fatigue, can increase the risk of common physical injuries, such as slips, trips, or falls.

6.6 Physical Fatigue/Exertion

The onset of fatigue generally occurs quicker while wearing protective suits because of the additional heat stress and weight of the suit. Tasks take longer and require more effort due to decreased vision, dexterity, and mobility. These aspects all result in increased physical exertion and fatigue thus decreasing worker performance. Other more serious illnesses such as stroke or heart attack may occur.

7.0 EPA LEVELS OF PROTECTION

While the following are guidelines for typical equipment to be used in certain circumstances, other combinations of protective equipment may be more appropriate, depending upon specific site characteristics.

7.1 Level A

Level A protection is required when the greatest potential for exposure to hazards exists and when the greatest level of skin, respiratory, and eye protection is required. The following are examples of appropriate Level A equipment:

- Positive pressure, full face-piece self-contained breathing apparatus (SCBA) or positive pressure supplied-air respirator with escape SCBA
- Totally encapsulating chemical-protective suit
- Inner and/or outer chemical-resistant gloves
- Chemical-protective boots
- Disposable protective suit, gloves, and boots.

The following situations require use of Level A protection:

- Hazardous substances have been identified and require the highest level of protection for skin, eyes, and the respiratory system.
- The atmosphere contains less than 19.5 percent oxygen.
- Site operations involve a high potential for splash, immersion, or exposure to unexpected materials that are harmful to the skin.
- Operations are being conducted in confined, poorly ventilated areas, and the absence of hazardous substances has not been determined.
- Direct reading instruments indicate high levels of unidentified vapors or gases in the air.

It may be necessary to base the decision to use Level A protection on indirect evidence. Other conditions that may indicate the need for Level A protection include:

- Work performed in confined spaces
- Suspected or known presence of highly toxic substances, especially when field equipment is not available to test concentrations
- Visible indicators such as leaking containers or smoking chemical fires
- Potentially dangerous tasks such as initial site entry.

7.2 Level B

Level B protection is required under circumstances requiring the highest level of respiratory protection, with a lesser level of skin protection. Potential Level B equipment includes:

- Positive pressure, full face-piece SCBA or positive pressure supplied-air respirator with escape SCBA
- Inner and/or outer chemical-resistant gloves
- Face shield
- Hooded chemical resistant clothing
- Coveralls

- Outer chemical-resistant boots.

The following situations require use of Level B protection:

- The type and atmospheric concentration of substances have been identified and require a high level of respiratory protection, but a lower level of skin protection than Level A.
- The atmosphere contains less than 19.5 percent oxygen.
- The presence of incompletely identified vapors and gases is indicated but they are not suspected of being harmful to the skin.

The use of Level B protection does not afford as great a level of protection to the skin and eyes as Level A, but it does provide a high level of respiratory protection. At most abandoned, outdoor hazardous waste sites, ambient atmospheric vapor or gas levels have not approached sufficiently high concentrations to warrant Level A protection. Therefore, Level B protection is often adequate.

7.3 Level C

Level C protection is required when the concentration and type of airborne substances is known, and the criteria for using air-purifying respirators is met. Typical Level C equipment includes:

- Full-face air-purifying respirators
- Inner and outer chemical-resistant gloves
- Hard hat
- Escape mask
- Disposable chemical-resistant outer boots.

Meeting any of the following criteria warrants use of Level C protection:

- The atmospheric contaminants, liquid splashes, or other direct contact will not adversely affect or be absorbed by the skin.
- The types of air contaminants have been identified, concentrations do not exceed IDLH levels or respirator limitations, and an air-purifying respirator is available that can remove the contaminants provided the contaminant has good warning properties.
- Oxygen concentrations are not less than 19.5 percent by volume and job functions do not require SCBA.

Level C protection is distinguished from Level B by the equipment used to protect the respiratory system assuming the same type of chemical-resistant clothing is used. The main selection criterion for Level C is that atmospheric concentrations and other selection criteria permit wearing an air-purifying respirator.

7.4 Level D

Level D is the minimum protection required. Appropriate Level D protective equipment may include:

- Gloves
- Coveralls
- Safety glasses
- Face shield
- Chemical-resistant, steel-toe boots or shoes.

Level D protection is primarily a work uniform. This protection is sufficient under the following conditions:

- No contaminants are present.
- Work operations preclude splashes, immersion, or the potential for unexpected inhalation of or contact with hazardous levels of any chemicals.

7.5 Reasons for Upgrading or Downgrading

In many instances, the level of protection which is designated for initial site assessment may be upgraded or downgraded depending upon the results of the site assessment and the status of the potential hazards. As site conditions change, the level of protective clothing required should be modified to reflect current conditions.

8.0 INSPECTION

An effective PPE inspection program should feature at least four different inspections:

- Inspection and operational testing of equipment received from the factory or distributor
- Inspection of equipment as it is issued
- Inspection before and after use or training and prior to maintenance
- Periodic inspection of stored equipment.

Individual identification numbers should be assigned to all reusable pieces of equipment and records should be maintained, by number, of all inspection procedures. At a minimum, each
inspection should record the date, inspector, and any unusual conditions or findings and corrective actions.

8.1 Inspection Procedures

Periodic inspection will cover different areas in varying degrees of depth. Detailed inspection procedures, where appropriate, are usually available from the manufacturer. The following inspection procedures can be used as a guide:

- Spread suit out on a flat surface.

- Examine the outside of the suit for the following:
  - Fabric for abrasions, cuts, holes, or tears
  - Fabric has retained the original flexibility and durability
  - Seams for separations or holes
  - Zippers, buttons, storm flaps, and other connecting devices for proper sealing and operation
  - Signs of previous chemical attack or incomplete decontamination (unusual discoloration, rough surface, gummy feeling, cracks)
  - Elastic around wrists and ankles and the drawstrings on hoods are in good condition (if applicable).

- Gloves and booties may be checked for rips or tears by inflating the garment and observing whether there are any leaks, as well as examining for cracks, holes, and checking the general condition (e.g., discoloration, gumminess).

9.0 DONNING AND DOFFING

Donning and doffing of protective clothing and equipment is a relatively simple task, but a routine must be established and practiced frequently. Not only do correct procedures help instill confidence in the wearer, they reduce the risk of exposure and the possibility of damage to the suit. It is especially important to remove the equipment systematically so as to prevent or minimize the transfer of contaminants from the suit to the wearer.

9.1 Donning

Since donning the ensemble can be difficult to perform alone and solo efforts increase the possibility of improper use and suit damage, assistance should be provided. The donning routine should be modified depending on the particular type of suit or the need for extra gloves or boots. Once the equipment has been donned, the fit should be evaluated. The clothing should not be too small, increasing the likelihood of tearing the suit material and accelerating worker fatigue. The clothing should not be too large, increasing the possibility of snagging the material and compromising the dexterity and coordination of the worker. In either case, clothing that fits should be provided.

9.2 Doffing

Exact procedures for removing PPE must be established and followed to prevent contaminant migration from the work area and transfer of contaminants to the wearer's body, the doffing assistant, and others. In general, these procedures should be performed

only after decontamination of the suited worker. However, in some situations (e.g., medical emergencies, extreme environmental conditions), doffing of contaminated suits may be necessary and procedures should be developed to address these occurrences. Both worker and assistant should avoid any direct contact with the outside surface of the contaminated suit throughout the decontamination procedures. If the suit is to be reused, the assistant should also avoid contact with the inside of the garment.

10.0 CONTROLLING THE TRANSFER OF CONTAMINANTS

Following established donning/doffing procedures will help prevent or minimize the transfer of contaminants from the suit to the wearer. In addition, proper decontamination procedures, including personal hygiene practices, must be followed. The extent and type of decontamination required will be dependant upon the contaminant(s) and site conditions. The decontamination Training course provides additional, general information concerning decontamination practices and procedures.

Specific decontamination techniques are covered during the in-depth training that is required to work at hazardous waste site operations and emergency responses.

11.0 MAINTENANCE AND STORAGE OF EQUIPMENT

In order to ensure proper operating condition, all PPE must be maintained and stored according to established procedures. Many equipment failures can be directly attributed to improper maintenance or storage practices.

11.1 Maintenance

The technical aspects of PPE maintenance procedures vary by manufacturer and type of equipment. Manufacturers frequently restrict the sale of certain PPE parts only to individuals or groups who are specially trained, equipped, and "authorized" by the manufacturer to purchase them. Explicit procedures should be adopted in the site workplan to ensure that the appropriate level of maintenance is performed only by individuals trained at that level.

11.2 Storage

Clothing and respirators must be stored properly to prevent damage or malfunction due to the following conditions:

- Exposure to dust: contaminates material
- Moisture: can break down materials; cause mold etc.
- Sunlight: damages material and increases aging

- Damaging chemicals: contaminates and breaks down materials
- Extreme temperatures: alters configuration of materials; melt (hot) or crack (cold) materials
- Impact: can damage, break, tear materials.

Procedures must be specified for both pre issuance warehousing and, more importantly, post issuance (in-use) storage.

12.0 SUMMARY

Protective clothing and equipment, used in conjunction with appropriate engineering or work practice controls, are designed to prevent exposure to a hostile environment or condition by providing a physical barrier between the worker and the hazard. The proper selection and use of protective clothing can minimize or eliminate the potential for detrimental effects to a worker. The types, styles, and levels of protection must be selected based on the hazards present at a site and used in combination with knowledge of appropriate inspection, maintenance and storage procedures, as well as recognition of associated stresses and limitations.

Key concepts presented in this module are:

- The importance of wearing and using appropriate personal protective clothing/equipment
- The different types and styles of PPE available
- The factors influencing the selection of PPE
- The proper use, including donning and doffing procedures, of PPE
- The relative importance of various performance requirements
- The limitations of PPE
- The potential stresses associated with the use of PPE
- The components of various levels of protection
- The appropriate inspection, maintenance, and storage practices for the PPE you may be required to use.

Measures you can take to protect yourself against potential hazards include:

- Be aware of the hazards you may encounter during field activities and have the proper PPE available.
- Make sure you understand the use and limitations of the PPE you may be required to use.
- If new hazards or new types of PPE are introduced, ensure that you receive the appropriate training.
- Maintain and store your PPE according to all relevant SOPs or manufacturers' instructions.

EXERCISE

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

1. Since PPE is more versatile, less expensive, and a quicker solution than engineering controls, it is regarded as an effective and efficient substitute which should be used if at all possible.

   a. True b. False

2. List the remaining five areas of protection for which PPE is used:
   _____, Eye and Face ,_____
   _____,_____, and _____.

3. Chemical protective clothing can be classified by:
   _____,_____, and _____.

4. List the ten performance requirements for chemical protective clothing.
   _____, _____
   _____, _____
   _____, _____
   _____, _____
   _____, _____

5. Chemical resistance, the most important performance requirement, is determined by:
   _____, _____, and _____.

6. The selection of chemical protective clothing is dependent upon several factors, including:

   a. Type of hazard
   b. Concentration of material
   c. Amount of time
   d. Size of the individual
   e. a, b, and c
   f. a, b, and d

7. The types of stresses and difficulties experienced by wearers of chemical protective clothing include: _____, _____, vision, _____,
   _____, and _____.

8. What level of protection must be used if the atmosphere contains less than 19.5 percent oxygen and the highest level of skin protection is required?

   a. Level A
   b. Level B
   c. Level C
   d. Level D

9. What level of protection should be used if oxygen concentrations are greater than 19.5 percent, contaminant concentrations do not exceed IDLH levels, and the contaminant is not a skin hazard?

    a. Level A
    b. Level B
    c. Level C
    d. Level D

10. Many equipment failures can be directly attributed to improper maintenance or storage practices.

    a. True b. False

EXERCISE KEY

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

1. Since PPE is more versatile, less expensive, and a quicker solution than engineering controls, it is regarded as an effective and efficient substitute which should be used if at all possible.

   a. True **b. False**

2. List the remaining five areas of protection for which PPE is used:

   Head, Eye and Face, Foot, Hearing, Hand, and Skin and Body

3. Chemical protective clothing can be classified by:

   Style, Protective Material, and Intended Use

4. List the 10 performance requirements for chemical protective clothing.

   Chemical resistance ***Cleanability***
   Durability ***Design***
   Flexibility ***Size***
   Temperature resistance ***Color***
   Service/Shelf Life ***Cost***

5. Chemical resistance, the most important performance requirement, is determined by: ***penetration, degradation, and permeation.***

6. The selection of chemical protective clothing is dependent upon several factors, including:

   a. Type of hazard
   b. Concentration of material
   c. Amount of time
   d. Size of the individual
   e. a, b, and c
   f. a, b, and d

7. The types of stresses and difficulties experienced by wearers of chemical protective clothing include: ***heat, communication,*** vision, ***dexterity, mobility, and physical fatigue/exertion.***

8. What level of protection must be used if the atmosphere contains less than 19.5 percent oxygen and the highest level of skin protection is required?

   a. Level A
   b. Level B
   c. Level C

d. Level D

9. What level of protection should be used if oxygen concentrations are greater than 19.5 percent, contaminant concentrations do not exceed IDLH levels, and the contaminant is not a skin hazard?

a. Level A
b. Level B
c. Level C
d. Level D

10. Many equipment failures can be directly attributed to improper maintenance or storage practices.

a. True b. False

APPENDIX A: GENERAL PHYSICAL CHARACTERISTICS OF SELECT MATERIALS*

Glove Resistance	Abrasion Resistance	Cut Resistance	Flexibility*	Puncture Resistance*	Tear Resistance*	Cost
Butyl Rubber (butyl)	F	G	G	G	G	High
Coated Tyvek®	F	P	G	P	F	Low
Natural Rubber	E	E	E	E	E	Medium
Neoprene	G	E	G	G	G	Medium
Nitrile Rubber (nitrile)	E	E	E	E	G	Medium
Polyethylene	F	F	G	P	F	Low
Polyvinyl Alcohol (PVA)	F	F	P	F	G	High
Polyvinyl Chloride (PVC)	G	P	F	F	G	Low
Responder®/						
Chemrel®/ Barricade	F	P	F	P	F-G	Low
Silver Shield®/4H®	F	P	F	F	F	Low
Viton	G	G	G	G	G	High

* Ratings are subject to variation depending on formulation, thickness, and whether the material is supported by fabric.

E = Excellent
G = Good
F = Fair
P = Poor