PERSONAL PROTECTIVE EQUIPMENT (PPE)

See also:

- SPECIFIC HAZARD ATTACHMENTS
- RI DEM RESPIRATOR POLICY AND PROGRAM

CONDITIONS FOR PROTECTION

While ER Staff will not usually work under worst-case conditions, they might be exposed to hazards as a normal part of their job. Their personnel protective clothing and equipment (PPE) should be based on the potential risk of exposure to these materials. ER Staff must be trained to work under these worst-case as well as less severe conditions.

In general, **Level A** involves worst-case conditions and maximum risk. The environment has the potential to be immediately dangerous to life and health (IDLH). Pressure-demand self- contained breathing apparatus and totally encapsulated chemical resistant suits are required. **Level D** involves emergency escape respiratory protection and minimum eye and skin protection.

Each member of the ER Staff will receive the safety equipment and protective clothing required for the particular levels of protection to which he/she has been trained. The Designated On-Scene Safety Officer (DOSSO) or his/her designee will assure that adequate safety equipment for each employee is available. No employee may participate in a field activity without adequate equipment or protective clothing.

The more specific types of hazards for which Levels A, B, C and D protection are appropriate are:

Level A protection should be used when:

- The hazardous substance has been identified and requires the highest level of protection for skin, eyes, and the respiratory system based on
  - the measured (or potential for) high concentration of atmospheric vapors, gases or particulates; or
  - the site operations and work functions involve a high potential for splash, immersion, or exposure to unexpected vapors, gases, or particulates of materials that are harmful to skin or capable of being absorbed through the skin; or
- Substances with a high degree of hazard to the skin are known or suspected to be present, and skin contact is possible; or
- Operations are being conducted in confined, poorly ventilated areas and the absence of conditions requiring Level A have not yet been determined.

Level B protection should be used when:

- The type and atmospheric concentration of substance are unknown or have been identified and require a high level of respiratory protection, but less skin protection; and
- The atmosphere contains less than 19.5 percent oxygen; or
- The presence of incompletely identified vapors or gases is indicated by a direct-reading organic vapor detection instrument, but vapors and gases are not suspected of containing high levels of chemicals harmful to skin or capable of being absorbed through the skin.

Note: This level entails atmospheres with IDLH concentrations of specific substances that present severe inhalation hazards and that do not represent a severe skin hazard; or that do not meet criteria for use of air purifying respirators.

Level C protection should be used when:

- The atmospheric contaminants, liquid splashes, or other direct contact will not adversely affect or be absorbed through any exposed skin; or
- The types of air contaminants have been identified, concentrations measured, and an air purifying respirator is available that can remove the contaminants; or
- All criteria for the use of air-purifying respirators are met.

Level D protection should be used when:

- The atmosphere contains no known or suspected hazard; and

- Work functions preclude splashes, immersion or the potential for unexpected inhalation of or the potential for unexpected inhalation of or contact with hazardous levels of any chemicals.

Areas of Protection	Level A	Level B	Level C	Level D
Respiratory	Maximum	Maximum	Moderate	Minimum
Skin	Maximum	Very High	Moderate	Minimum
Eye	Maximum	Very High	Moderate	Minimum

REEVALUATING LEVELS OF PROTECTION

The type of environment and the overall level of protection should be reevaluated periodically as the amount of information about the site increases and as workers are required to perform different tasks.

Reasons to Upgrade to a Higher Level (D is lowest, A is highest)

- Known or suspected presence of dermal hazards
- Occurrence or likely occurrence of gas or vapor emission
- Change in work task that will increase contact or potential contact with hazardous materials
- Request of the individual performing the task

Reasons to Downgrade to a Lower Level:

- New information indicating that the situation is less hazardous than was originally thought
- Change in site conditions that decreases the hazard
- Change in work task that will reduce contact with hazardous materials

LEVELS OF PERSONAL PROTECTIVE EQUIPMENT (PPE)

Protective equipment to protect the body against contact with known or anticipated chemical hazards has been divided into four categories, with the following required and optional (*) components.

Level A Protection (Highest)

Level A protection should be worn when the highest level of respiratory, skin, eye and mucous membrane protection is needed. The following constitute Level A equipment that should be used as appropriate:

- Positive-pressure, full-face-piece, self-contained breathing apparatus (SCBA) or positive-pressure, supplied-air respirator that has been approved by the National Institute for Occupational Safety and Health (NIOSH), with escape SCBA.
- Fully encapsulating chemical protective suit.
- Gloves, inner, chemical-resistant.
- Gloves, outer, chemical-resistant.
- Chemical-resistant boots with steel toe and shank (depending on suit construction, worn over or under suit boot.)
- Disposable protective suit, gloves and boots (depending on suit construction) over totally-encapsulating suit. *
- Underwear, cotton, long-john type. *
- Hard hat (under suit). *
- Coveralls (under suit). *
- Two-way radio communications (intrinsically safe/non-sparking). *

Level B Protection

Level B protection should be selected when the highest level of respiratory protection is needed, but a lesser level of skin and eye protection. Level B protection is the minimum level recommended on initial site entries until the hazards have been further identified and defined by monitoring, sampling, and other reliable methods of analysis, and equipment corresponding with those findings utilized. The following constitute Level B equipment that should be used as appropriate:

- ❑ Positive-pressure, full-face-piece, self-contained breathing apparatus (SCBA); or positive-pressure, supplied-air respirator (NIOSH approved).with escape SCBA.
- ❑ Chemical-resistant clothing (overalls and long-sleeved jacket, coveralls, hooded two-piece chemical splash suit, disposable chemical-resistant coveralls.)
- ❑ Gloves, outer, chemical-resistant.
- ❑ Gloves, inner, chemical-resistant.
- ❑ Chemical-resistant boots with steel toe and shank.
- ❑ Coveralls (under splash suit). *
- ❑ Chemical-resistant (disposable) boot covers. *
- ❑ Two-way radio communications (intrinsically safe). *
- ❑ Hard hat. *
- ❑ Faceshield.*

Level C Protection

Level C protection should be selected when the type of airborne substance is known, concentration measured, criteria for using air-purifying respirators met, and skin and eye exposure is unlikely. Periodic monitoring of the air must be performed. The following constitute Level C equipment that should be used as appropriate:

- ❑ Full-face or half-mask, air-purifying respirator (NIOSH approved).
- ❑ Chemical-resistant clothing (one piece coverall, hooded two piece chemical splash suit, chemical resistant hood and apron, disposable chemical-resistant coveralls.)
- ❑ Gloves, outer, chemical-resistant.
- ❑ Gloves, inner, chemical-resistant.
- ❑ Chemical-resistant boots with steel toe and shank.
- ❑ Chemical-resistant, disposable boot covers. *
- ❑ Cloth coveralls (inside chemical-protective clothing). *
- ❑ Two-way radio communications (intrinsically safe). *
- ❑ Hard hat. *
- ❑ Escape mask. *
- ❑ Faceshield. *

Level D Protection (Lowest)

Level D is primarily a work uniform, affording minimal protection, used for nuisance contamination only. It requires only coveralls and safety shoes/boots. Other PPE is based upon the situation (types of gloves, etc.) Level D protection should not be worn on any site where respiratory or skin hazards exist. The following constitute Level D equipment that should be used, as appropriate

- ❑ Coveralls.
- ❑ Gloves.
- ❑ Chemical-resistant boots or shoes with steel toe and shank.
- ❑ Disposable, chemical-resistant boot covers.
- ❑ Safety glasses or chemical splash goggles.
- ❑ Hard hat.

- ❑ Escape mask.
- ❑ Faceshield.

Note: Combinations of personal protective equipment other than those described for Levels A, B, C and D protection may be more appropriate and may be used to provide the proper level of protection in specific situations.

ELEMENTS OF PPE

The selection of appropriate protective gear is based on the hazards anticipated or recognized. Complete protection calls for assembling a set of gear including respirator, hardhat, safety glasses or faceshield (preferably both), body covering (coveralls, pants and jacket), gloves and safety boots/shoes (steel toe and shank). Omitting one item may compromise the individual's safety. Some pieces of protective equipment, such as hardhats and boots, have specific standards for manufacture and only those items meeting these standards should be used. However, there are no such standards for chemical protective clothing. Selections must be based upon judgment of the DOSSO.

Head Protection

The **hardhat**, a basic piece of safety equipment used in any work operations, must meet ANSI Z89.1 1986 specifications for protection. Manufacturers have adapted hardhats so that ear protection and faceshields may be easily attached. Hardhats are adjustable so a liner can be worn during cold weather. A **chin strap** is advantageous when work involves bending and ducking. It also helps secure the hardhat to the head when full-face masks are worn. Hard hats should be worn whenever physical hazards exist or where they are required by the site plan governing the area in which ER Staff are working.

Faceshields that attach to hardhats provide added protection. A combination that leaves no gap between the shield and the brim of the cap is best because it prevents overhead splashes from running down inside the faceshield. The faceshield must meet ANSI Z87.1-1989 specifications.

Eye Protection

Safety glasses must also meet ANSI Z87.1-1989. They should be standard safety gear when the respiratory protection is a half-face mask with no faceshield. Both safety glasses/goggles and a faceshield are advisable as long as they do not impair visibility. Safety glasses should be of the type that incorporates faceshields.

Safety glasses should be worn whenever physical hazards exist and/or where they are required by the site plan governing the area in which ER Staff are working. Safety glasses should be worn where there is a chance of flying objects or where splash hazards exist. The DEM will provide plain or prescription safety glasses depending on the needs of the individual. **Contact lenses** should not be worn in areas in which chemical hazards exist. In activities (such as grinding) where corrosive chemicals or flying objects are expected to be encountered, **faceshields** and **goggles** should be worn in combination. This combination can provide excellent protection for the eyes as well as the whole face.

Ear Protection

Earplugs or **muffs** should be issued when noise may be a problem, such as around heavy machinery and impact tools. Hearing protection should be used where sound levels are greater than or equal to 85 dBA, as is likely within 15 feet of operating heavy equipment or generators. Earmuffs are especially recommended for persons working in areas where sound levels exceed 105 dBA (e.g., near high-volume pumps, skid units, pile drivers, jack hammers, impact tools, grinders, saws).

Foot Protection

Footwear worn during site activities (including leather work boots and rubber boots) must meet the specifications of ANSI Z41-1991. The material used to make the boots is not subject to any standards. Protection against liquid hazardous chemicals requires a boot of neoprene, PVC, butyl rubber, or some other chemical resistant material. (See "Effectiveness of Protective Materials Against Chemical Degradation" below.) **Boots** are available in two styles: pullover and shoeboot. Pullovers may be inexpensive enough to be considered disposable; otherwise they must be completely decontaminated. With chemical resistant boots, the pant leg should be outside and over the boots to prevent liquids from entering. All **work boots** should be steel toed. Steel shanks should be included for those employees who are expected to climb ladders or travel over sharp protruding objects. Disposable **boot covers** should be worn at sites where hazardous materials may contaminate footwear. Boot covers can protect work boots or rubber boots from contamination. Boot covers tend to be thin and puncture easily, so they should not be relied upon as the only source of protection. **Rubber boots with steel toes** should be worn at all sites where hazardous materials may contaminate the apparel. Boots should be decontaminated before they are returned to the office for storage, or disposed of on site.

Hand Protection

The hands are as susceptible to contamination as the feet. **Gloves** must resist puncturing and tearing as well as provide the necessary chemical resistance.

Disposable gloves should be worn while collecting samples to protect both the employee and the sample from contamination. Wearing two pairs are recommended. A disposable under glove should be worn whenever a thick protective over glove is required.

An **over glove** should be worn when physical contact with toxic material is anticipated. The over glove should be made of a material that is impermeable to the chemicals at the site.

Leather or heavy cotton over gloves can be used as a work glove over a protective glove. These gloves provide a better holding surface while working but do not protect the worker from chemical exposure. If they become contaminated, they should be discarded because leather and cotton are difficult to decontaminate.

Jacket **cuffs** should be worn over glove cuffs to prevent any liquid from spilling into the gloves. If hands are elevated above the head during work, the gloves should be sealed with **tape** to the coveralls or splashsuit.

When selecting gloves consider thickness and cuff length. The thicker and longer the glove the greater the protection. However, the material should not be so thick that it interferes with the necessary dexterity.

Two pair of gloves should also be considered for extra protection of the hands if the outer glove is torn or permeated. A pair of **inner gloves** also adds an extra layer of protection for the hands during the removal of outer gloves and other chemically protective items. (See "Effectiveness of Protective Materials Against Chemical Degradation" below)

Body Protection

Clothing to protect the body against hazardous liquids, gases, or vapors is available in a variety of styles and materials.

If the hazard present is known to be minor or simply a nuisance, minimal protection is warranted. This may be in the form of garments of **Tyvek** which are disposable or **Nomex** which are durable. Both are available as **coveralls** suitable for field use. As the hazards to the body increase, so does the level of protection needed. A splash suit made of **PVC** is suitable for a liquid such as an acid or base or when there will be minimal contact with organic materials. Some are inexpensive enough to be disposable. If the material is more toxic, then more protection must be utilized. Splash suits similar in design to the PVC splash suits are good barriers against toxic hazards. These are made of neoprene and butyl rubber.

Toxic vapor/gases require the most complete protection, the best being fully encapsulating suits. The suit must not allow any penetration or permeation. Zippers must be properly sealed and seams properly connected and sealed to protect against vapors. Fully encapsulating suits also require the basic safety items such as safety boots and hardhat, along with a source of breathing air.

The range of ER attire and their functions include:

- **DEM windbreaker**. It provides partial protection against particulate contaminant exposures and identifies the person as a DEM employee. It provides poor, if any, protection against hazardous liquids.
- **Orange safety vest**. It is to be used in situations where visibility is necessary
- **Cloth coveralls.** They have an open weave that allows particles, liquids and vapors to pass through easily. Cloth coveralls are useful only to protect street clothes from getting soiled and are not to be used as protection against exposure to hazardous material.
- **Chemical splash suits.** They can be selected according to the hazard. The Designated On-Scene Safety Officer (DOSSO) or DEM ER Administrator will assist in the selection, if there is a need for these suits.
- **Tyvek suits**. They offer protection against particulate contaminants and other nuisances. They provide very limited protection against liquids.
- **Saranex suits**. They protect against some types of liquid hazards. They are made of very good general-purpose disposable material (Tyvek wrapped with Saran).

- Snake **leggings** are available upon request for any ER Staff who must perform field investigations in rural areas where biting pests are expected.

Note that wearing protective clothing creates some problems, the main one being that the body is shielded from normal circulation of air. Perspiration does not evaporate, thus eliminating the body's main mechanism for cooling. A cool towel on the back of the neck will effectively cause the hypothalamus (the body's thermostat) to reduce the body's temperature immediately by 2-4 degrees in a heat stress situation. Otherwise, the body is prone to heat stress, including heat stroke, which can be fatal. Heat related problems are very common when temperature rises above 75 degrees F. Work schedules for persons wearing fully encapsulating clothing must be closely and conservatively regulated lest heat stress becomes more of a threat than the chemical hazard itself.

The best way to combat heat stress is to allow the body to cool normally. The most efficient body cooling process is by evaporation. While wearing protective clothing that has no ventilation people perspire profusely. If the perspiration remains in contact with the skin, it has a better chance of evaporating and cooling the body surface. If the perspiration is allowed to run off the body quickly, less evaporation occurs. This happens when shorts are worn under a fully encapsulating suit.

Suit material can become very hot and cause severe burns if it contacts the wearer's bare skin. Long cotton underwear is a good solution to this problem. It clings to the body when soaked with perspiration, thus allowing the greatest amount of cooling by evaporation and also protects the body from burns caused by the suit itself.

During extended periods of work in fully encapsulating suits, some sort of "cooling" must be provided to the wearer. The best method is to schedule frequent rest periods. If this is not adequate, a cooling device should be employed. Effective cooling units are available for use with supplied-air units. A vortex tube separates the air into cool and warm components, releasing the warm air outside the suit. When self-contained air is used for breathing, the cooling device must also be self-contained. For example, vests have been designed to carry ice packs. There are other commercial devices available to combat heat generated by fully encapsulating suits.

Drowning Protection

A **personal flotation device** (PFD) is to be worn whenever the employee travels by vessel or must work near water and there is a threat of drowning.

Breathing Protection

An air-purifying **respirator** is a personal protective device used to control airborne contaminants that cannot be reduced to safe levels by engineering control. It filters airborne contaminants by the use of various filters. An emergency escape pack should be used in conjunction with an air-purifying respirator. **SEE “RESPIRATOR PLAN”**

Escape Protection

An **emergency escape pack** is a personal protective device carried when entering an area in Level C or D. The escape pack is to be used in an emergency situation where there is an atmospheric change that may cause an inhalation hazard. Emergency escape packs are not required if a SCBA is available or being used. A **SCBA** supplies air to the wearer and provides the greatest respiratory protection. Situations that require SCBAs are unknown atmospheres, toxic gas clouds, and confined spaces. A SCBA is provided to any DEM ER Staff who has the training and desire to use it. Refer to the DEM ER Respirator Plan for further information.

PPE PERFORMANCE REQUIREMENTS

The selection of appropriate protective gear is based on the hazards anticipated or recognized. Protective clothing protects primarily because of the material from which it is made. In selecting the protective material, the following qualities should be considered:

- **Chemical resistance**, which is the most important. When clothing contacts a hazardous material, it must maintain its structural integrity and protective qualities
- **Strength,** which is based on resistance to tears, punctures, and abrasions, as well as tensile strength.
- **Flexibility**, which is ease of movement that the clothing affords. Flexibility is especially important in glove materials.
- **Thermal limits**, which affect the ability of clothing to maintain its protective capacity in temperature extremes. Thermal limits also affect mobility in cold weather and transfer of heat to the wearer in hot weather.
- **Cleanability**, which is difficult and expensive if protective clothing is not cleanable. Some materials are nearly impossible to clean adequately under any circumstances. Disposable clothing is sometimes used.
- **Lifespan**, which is the ability to resist aging, especially in severe conditions over time. This should be balanced against the initial cost of the garment.

In applying these criteria, the following considerations are recommended:

Chemical Resistance

Protective material must be able to resist degradation, penetration, and permeation by the contaminant. Any of these actions may result upon contact, depending on factors such as concentration and contact time.

Degradation

Degradation is the result of a chemical reaction between the contaminant and the protective material. Damage to the material may be slight or as severe as complete deterioration. The reaction may cause the material to shrink or swell, become brittle or very soft, or completely change its chemical and physical structure. Changes such as these may enhance or restrict permeation or allow penetration by the contaminant.

Tables are available indicating relative effectiveness of various protective materials against generic classes of chemicals (e.g., see Chart below). Most tables only reflect ability to resist degradation. A protective material may resist degradation by a contaminant, but still be very permeable to it. Such charts are useful when used with discretion and when the seriousness of the hazard is properly evaluated. If a chemical is extremely toxic, then any activity involving it should be re-evaluated.

EFFECTIVENESS OF PROTECTIVE MATERIALS AGAINST CHEMICAL DEGRADATION (BY GENERIC CLASS)

Protective Material Chemical Class	Butyl Rubber	Polyvinyl chloride	Neoprene	Natural Rubber
Alcohols	E	E	E	E
Aldehydes	E-G	G-F	E-G	E-F
Amines	E-F	G-F	E-G	G-F
Esters	G-F	P	G	F-P
Ethers	G-F	G	E-G	G-F
Fuels & Solvents	F-P	G-P	E-G	F-P
Halogenated Hydrocarbons	G-P	G-P	G-F	F-P
Hydrocarbons	F-P	F	G-F	F-P
Inorganic acids	G-F	E	E-G	F-P
Inorganic bases & salts	E	E	E	E
Ketones	E	P	G-F	G-F
Natural fats and Oils	G-F	G	E-G	G-F
Organic acids	E	E	E	E

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

Source: *Survey of Personal Protective Clothing and Respiratory Apparatus.* DOT, USCG, Office of Research and Development (September 1974).
http://www.ehso.com/OSHA_PPEchart.htm

Penetrability

A chemical penetrates a protective garment because of its design and construction imperfections, not because of the inherent material from which it is made. Stitched seams, button holes, porous fabric, and zippers can provide an avenue for the contaminant to penetrate the garment. A well designed and constructed protective suit with self-sealing zippers and lapped seams made of a nonporous degradation-resistant material prevents penetration, but as soon as the suit is ripped or punctured it loses its ability to prevent penetration. A material may also be easily penetrated once degraded.

Permeability

The ability of a protective material to resist permeation is an inherent property. A contaminant in contact with the protective material establishes a concentration gradient. The concentration is high on the contact surface and low inside.

Because the tendency is to establish equilibrium, diffusion and other molecular forces "drive" the contaminant into the material.

When the contaminant passes through the material to the inside surface, it condenses there. The process of permeation continues as long as the concentration remains greater at the contact surface. The permeation rate is based on several factors. Rate is inversely proportional to the thickness of the material and directly proportional to the concentration of the contaminant.

Permeability data are available from manufacturers and independent testing laboratories. If there is a question about permeability of a material in contact with a specific contaminant, a sample swatch of the material should be tested by a recognized laboratory for permeability to that chemical.

The amount or degree of permeation is related to the exposure conditions, especially contact time, which ultimately dictates how much of the contaminant permeates the protective material. Thus a conscious effort should be made to avoid prolonged exposure or contact with any hazardous contaminant, even when wearing protective clothing. No material resists permeation by all agents.

Decontamination

Once a contaminant contacts a protective material, the garment must be decontaminated. With many materials, it is impossible to completely remove all contamination. Materials such as butyl rubber and Viton, which can be effectively decontaminated and cleaned, are also expensive. In some situations disposable clothing may be advantageous.