

FACT SHEET: Personal Protective Equipment Levels and Risks

October 2004

Personal protective equipment (PPE) for chemical hazards consists of a chemical protective clothing ensemble and respiratory protection. OSHA and EPA regulations define the specific requirements for PPE and classify PPE into four levels, A-D, each for use in given circumstances (see Table 1). OSHA and EPA regulations were coordinated when written and do not differ in their definitions.¹ Appropriate PPE is chosen based on the physical and chemical properties of the product involved, a risk assessment of the situation, the work to be done, and the capabilities of the wearer². Use of PPE is not without cost - visibility and mobility are limited, and the wearer undergoes significant physical stress. Training in care and use of PPE is essential to allow the user to safely recognize the limitations of PPE and handle the stresses involved.

The purpose of PPE is to protect the wearer against the effects of toxic or corrosive products, whether vapors, liquids, or solids, that could enter the body (via inhalation or skin absorption) or cause tissue damage upon contact with the skin. A single PPE material is not compatible with every chemical. While a particular material may provide excellent resistance against one chemical, the same material may provide very poor or no protection against another chemical. For example, outer gloves made of polyvinyl alcohol provide good resistance against butane, hexane, and toluene, but will break down when exposed to water. After determining a compatible material, the appropriate level of PPE must be determined. Level A is selected when the greatest level of skin, respiratory, and eye protection is required. Level B is selected when the highest level of respiratory protection is necessary but a lesser level of skin protection is needed. Level B may also be selected when site hazards cannot be fully assessed.³ Level C is selected when the concentration(s) and type(s) of airborne substance(s) are known and criteria for using air-purifying respirators are met. Level D is a work uniform affording minimal protection, used for nuisance contamination only. Structural firefighters' protective clothing with self-contained breathing apparatus (SCBA) may provide limited protection against some hazards, but is generally considered Level D.

Given the hazards of wearing PPE, selection of an appropriate level of protection is critical. Widely used training references emphasize that too much protection is as bad as too little, and state that appropriate assessment of PPE requirements is essential:

"In general, the greater the level of chemical protective clothing, the greater the associated risks. For any given situation, equipment and clothing should be selected that provide an adequate level of protection. Overprotection as well as under-protection can be hazardous and should be avoided."⁴

"[PPE] must be used carefully, since there are hazards associated with its use. 'The most significant hazard in the system is often the user who has unrealistic expectations of the protective clothing.'"⁵

"Among other things; personal protective equipment can provide the wearer with a false sense of security. The protected internal environment of a totally encapsulating suit can also induce rapid fatigue and heat stress, limit vision, and impair communications. Avoiding under-protection is a vital concern for the HAZMAT responder, but over-protection can cause its own needless hardship affecting a responder's stamina and effectiveness."⁶

¹ The U.S. Army has now adopted OSHA/EPA definitions, but previously used a significantly different proprietary letter code system to describe PPE levels. Some industry hazard communication systems also assign letter codes differing from OSHA/EPA definitions to PPE ensembles.

² A Site Characterization Fact Sheet is under development.

³ 29 CFR 1910.120(c)(5)(iii): "If the preliminary site evaluation does not produce sufficient information to identify the hazards or suspected hazards of the site, an ensemble providing protection equivalent to Level B PPE shall be provided as minimum protection, and direct reading instruments shall be used as appropriate for identifying IDLH [Immediately Dangerous to Life and Health] conditions."

⁴ *OSHA Technical Manual* TED 1-0.15A January 20, 1999, Section 8, Chapter 1

⁵ Hildebrand, Noll, and Yvorra, *Hazardous Materials: Managing the Incident*, Fire Protection Publications, Oklahoma State University, 1995, p. 314

⁶ *NFPA Hazardous Materials Response Handbook*, National Fire Protection Association, p. 29

FACT SHEET: Personal Protective Equipment Levels and Risks

October 2004

Use of PPE causes both psychological and physiological stress to the wearer; stress is a key factor in choosing appropriate PPE. Stress to the wearer, rather than the resistance of the ensemble to the chemical challenge of the product or the duration of the air supply, may be the limiting factor in how long a user can work in the ensemble. The National Institute for Occupational Safety and Health (NIOSH), the Federal agency responsible for conducting research and making recommendations for prevention of work-related disease and injury, conducted studies of workers wearing PPE. NIOSH found that even at low work intensities (equivalent to walking at an average speed) in moderate temperature and humidity conditions, worker tolerance time was reduced by 56%.⁷ Because of the physical stresses involved, regulations require a medical surveillance program for those wearing PPE or respirators. A physician must certify that any particular worker may wear a respirator. Common practice in the industry and fire service hazardous materials response community is to check workers' respiration rate, pulse, and blood pressure when PPE is donned and prohibit workers from wearing PPE should vital signs vary greatly from the normal range. Some screening protocols also include core temperature and cardiac monitoring.

Heat stress and illness are a major concern when personnel are working in chemical-protective clothing. The body's principal means of cooling is through the evaporation of sweat. When personnel are working in chemical-protective clothing, sweat is trapped inside the clothing and cannot evaporate. This will raise the body's core temperature and can result in heat-related illness. Being in good physical condition, maintaining adequate hydration, allowing adequate cool down between work periods, and limiting the duration personnel work in PPE may reduce heat stress, as may the use of a cooling vest or garment that slows the heating of the body using a circulating fluid or replaceable cold packs. In addition, wearing PPE affects the worker's attitude and ability to perform work. Personnel may feel claustrophobic when wearing a chemical-protective garment or respiratory protection. The bulk of most ensembles will make movement more difficult. Multiple gloves will compromise manual dexterity - OSHA regulations require wearing inner and outer gloves (both chemical-resistant), at a minimum; specific work functions may require additional hand protection. The face piece of the respirator reduces peripheral vision, and fogging of the face piece may further impair vision.

Use of a respirator can affect a wearer's health; a worker who may otherwise be able to perform a particular task may not be able to do so if a respirator is required. A significant portion of the populace will be unable to wear respiratory protective devices for medical reasons. Persons with severe pulmonary emphysema, asthma, coronary artery disease, and other maladies may be placed at risk if asked to wear respirators.⁸ Respirators with close-fitting masks must be fit-tested to ensure a good seal; a respirator will not be effective if not fitted properly. Under existing worker safety regulations, fit tests are required at least annually.⁹ The mask size required may change over time as the wearer ages. Persons with facial hair may not be able to achieve a proper fit; alternate arrangements would be necessary for those who must wear facial hair for religious or medical reasons. Facial deformities, the lack of teeth or dentures, and the wearing of eyeglasses can also compromise respirator mask seals.¹⁰ All supplied air respirators, as required for levels A and B, have tight-fitting face pieces. Powered air purifying respirators, for use in Level C, may have either tight-fitting face pieces or loose-fitting hoods. The loose-fitting powered air-purifying respirators do not require fit tests.

⁷ NIOSH Guide to Industrial Respiratory Protection, September 1987 (DHHS (NIOSH) Publication No. 87-116), Chapter 5, Section H.

⁸ NIOSH Guide to Industrial Respiratory Protection, September, 1987 (DHHS (NIOSH) Publication No. 87-116), Chapter 4, part III-B-2

⁹ 29 CFR 1910.134

¹⁰ NIOSH Guide to Industrial Respiratory Protection, September, 1987 (DHHS (NIOSH) Publication No. 87-116), Chapter 5

FACT SHEET: Personal Protective Equipment Levels and Risks

October 2004

Table 1. Comparison of PPE by Level

	Level A	Level B	Level C
Consists of: ¹¹	<ul style="list-style-type: none"> • Positive pressure, full face-piece self-contained breathing apparatus (SCBA), or positive pressure supplied air respirator with escape SCBA, (NIOSH approved). • Totally encapsulating chemical-protective suit. • Coveralls. (Optional) • Long underwear. (Optional) • Gloves, outer, chemical-resistant. • Gloves, inner, chemical-resistant. • Boots, chemical-resistant, steel toe and shank. • Hardhat (under suit). (Optional) • Disposable protective suit, gloves and boots (depending on suit construction, may be worn over totally-encapsulating suit). 	<ul style="list-style-type: none"> • Positive pressure, full-face piece self-contained breathing apparatus (SCBA), or positive pressure supplied air respirator with escape SCBA (NIOSH approved). • Hooded chemical-resistant clothing (overalls and long-sleeved jacket; coveralls; one or two-piece chemical-splash suit; disposable chemical-resistant overalls). • Coveralls. (Optional) • Gloves, outer, chemical-resistant. • Gloves, inner, chemical-resistant. • Boots, outer, chemical-resistant steel toe and shank. • Boot-covers, outer, chemical-resistant (disposable). (Optional) • Hardhat. (Optional) • Face shield. (Optional) 	<ul style="list-style-type: none"> • Full-face or half-mask, air purifying respirators (NIOSH approved). • Hooded chemical-resistant clothing (overalls; two-piece chemical-splash suit; disposable chemical-resistant overalls). • Coveralls. (Optional) • Gloves, outer, chemical-resistant. • Gloves, inner, chemical-resistant. • Boots (outer), chemical-resistant steel toe and shank. (Optional) • Boot-covers, outer, chemical-resistant (disposable) (optional). • Hardhat. (Optional) • Escape mask. (Optional) • Face shield.
Appropriate When:	<ul style="list-style-type: none"> • The hazard is identified as one that requires the highest level of protection for skin, eyes, and respiratory system. • High concentration of gases and vapors are present. • There is a high potential for splash, immersion, or exposure to unexpected gases/vapors/ particulates that are harmful to the skin or are capable of being absorbed through the skin. • Operations are being conducted in confined, poorly ventilated areas, and the absence of conditions requiring Level A have not yet been determined. 	<ul style="list-style-type: none"> • The highest level of respiratory protection is necessary but a lesser level of skin protection is needed. • The preliminary site evaluation does not produce sufficient information to identify the hazards or suspected hazards of the site • Atmospheric contaminants, liquid splashes, or direct contact will not adversely affect or be absorbed through any exposed skin. • 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. 	<ul style="list-style-type: none"> • Atmospheric contaminants, liquid splashes, or direct contact will not adversely affect or be absorbed through any exposed skin. • Air contaminants have been identified and measured and can be removed by an air-purifying respirator. • The atmosphere is not oxygen-deficient
Disadvantages:	<ul style="list-style-type: none"> • Garments tend to be more bulky (in order to be large enough to cover the wearer and self-contained breathing apparatus). • Visibility is reduced by the location and design of the face shield. • Suits weigh more than garments of other designs since a greater amount of fabric required and heavier fabric weights are used. • SCBA weight is about 40 lbs for a self-contained breathing apparatus with a "1 hour" cylinder, the largest generally available. • It has a very short "stay-time," or effective working time (less than 30 minutes) with a "1 Hour" SCBA. 	<ul style="list-style-type: none"> • Level B ensembles provide splash protection only. • SCBA weight is about 40 lbs for a self-contained breathing apparatus with a "1 hour" cylinder, the largest generally available. • It has a very short "stay-time," or effective working time (less than 30 minutes) with a "1 Hour" SCBA. • If a supplied-air respirator is used, distance from the air source is restricted and the air lines must be carefully managed. • SCBA or supplied-air respirator components may be exposed to contamination or chemical damage • Provisions must be made to refill/re-supply air cylinders 	<ul style="list-style-type: none"> • Level C ensembles provide splash protection only. • Air-purifying respirators can only be used in defined conditions. Factors precluding their use are: <ul style="list-style-type: none"> ○ Atmospheres immediately dangerous to life and health (IDLH). OSHA defines IDLH as "an atmospheric concentration of any toxic, corrosive, or asphyxiant substance that poses any immediate threat to life or would cause an irreversible or delayed adverse health effect or would interfere with an individuals ability to escape from a dangerous atmosphere." ○ Oxygen-Deficient Atmospheres. OSHA defines oxygen deficiency as less than 19.5% oxygen by volume in the atmosphere.

¹¹ 29CFR1910.120 Appendix B - General Description and Discussion of the Levels of Protection and Protective Gear (July 1 2003 edition)

FACT SHEET: Personal Protective Equipment Levels and Risks

October 2004

	Level A	Level B	Level C
	<ul style="list-style-type: none"> • If a supplied-air respirator is used, distance from the air source is restricted and the air lines must be carefully managed to avoid kinking, physical damage, chemical damage, or becoming a trip hazard. • The vapor-tight garment places a significant physical and physiological burden on the wearer, because sweat cannot evaporate and cool the body. Humidity inside quickly increases to near 100%. • Extreme care must be taken while donning and wearing the vapor-tight garment to avoid compromising exhalation valves. If exhalation valves are installed improperly or obstructed, the suit may inflate with the user's exhaled air, affecting visibility and dexterity and potentially compromising seals. • Provisions must be made to refill/re-supply air cylinders • Use requires significant support staff, including at least one person to assist each suited team member. Suit closures are on the outside and assistance is required when donning and doffing the suit. Additional decontamination line workers may be needed to assist suited members through the decontamination process since mobility and visibility are likely to be degraded through wear of the ensemble. • Periodic pressure testing is required. 		<ul style="list-style-type: none"> ○ Unknown products. Selection of the appropriate APR cartridge requires that the product be known. ○ Unknown concentrations. APR cartridges are suitable for a specific concentration range. If the concentration exceeds this range, protection will be compromised. ○ A concentration of a known substance that exceeds the protective capability of the APR or cartridge. ○ Products that present a health risk at concentrations below their odor or taste threshold. These products have poor warning properties. This is critical, as air-purifying respirator cartridges have no end of life warning other than load up (clogging of the cartridge preventing air passage) and agent breakthrough. ○ High moisture concentration, which may cause excessive load up. ○ Unavailability of the proper cartridge. Cartridges are product- or chemical group- specific. Cartridges made by different manufacturers may not be interchanged. • NIOSH approvals for air purifying/powered air purifying respirators are specific to the cartridge attached – changing cartridges, even to a different cartridge from the same manufacturer, may result in a non-approved respirator. • Powered air-purifying respirators require charged batteries
Advantages:	<ul style="list-style-type: none"> • A totally encapsulating suit protects the SCBA from contamination or chemical damage. • Totally encapsulating garments are easier to decontaminate, as there are fewer places for contaminants to be trapped. • May be used in oxygen-deficient atmospheres 	<ul style="list-style-type: none"> • Lighter and less bulky than level A • Easier to don than level A • Same chemical protective garment can be often used for both level B and level C ensembles (changing respiratory protection as appropriate), reducing training and inventory requirements • May be used in oxygen-deficient atmospheres 	<ul style="list-style-type: none"> • Longer stay times are possible, since respiratory protection is provided by chemical filter cartridges and not via a finite container of compressed air. • Suits weigh less due to their “coverall” design and thinner fabric. • Air-purifying respirators are lighter and smaller than SCBA, and do not require air line management like supplied-air respirators • No provisions for air supply required • Same chemical protective garment can be often used for both level B and level C ensembles (changing respiratory protection as appropriate), reducing training and inventory requirements