

Introduction

The use of chemical protective clothing (CPC) is only one aspect of a comprehensive program for ensuring the safety and health of workers. Careful planning, work practices, engineering (isolation) and administrative (avoidance) controls should also be considered. In fact, they are required by the Occupational Safety and Health Administration (OSHA) under 29 CFR 1910.120 as a preliminary step in limiting worker exposure to hazards. If circumstances prohibit the use of engineering controls or work practices, or these measures do not sufficiently reduce worker exposures, OSHA mandates that personal protective equipment (PPE) be used. Once the need for PPE is established, a careful evaluation of the hazards is necessary so a selection can be made to minimize the risk to the user. For chemical situations, knowing the hazard includes being aware of the type(s) of chemical, level of exposure (or potential exposure), physical state (liquid, solid or gas), and physiological effect(s) (toxic, carcinogen, asphyxiate, corrosive, etc.). However, when responding to a spill, much of this information is not known. In a situation like this, the highest level of protection is needed.

Levels of Protection

To help users choose a total PPE package, the Environmental Protection Agency (EPA) Office of Emergency and Remedial Response has determined four

levels of chemical risks. These levels range from unknown or highly hazardous, which requires complete protection, to non-hazardous, which requires only basic work attire.

Level A provides the highest level of skin and respiratory protection available. The CPC must be gas-tight, vapor-tight and splash-resistant. It is worn when there is a possible threat to life and health, or during operations dealing with an unknown hazard, such as during spill response and cleanup.

Level B offers protection from chemical splash, but does not prevent exposure to gases or vapors. The CPC may or may not be completely encapsulating, since a lower level of skin protection is required.

Level C features the same type of clothing as Level B, but has a lower level of respiratory protection. An air-purifying respirator is used in place of an SCBA. This level is used when the chemicals are known and it has been established that an air-purifying respirator is appropriate protection for the hazard.

Level D offers the lowest level of protection and is used when no potential or actual hazard exists. It offers minimal protection for nuisance exposure. (Refer to Table A and also OSHA 29 CFR 1910.120 Appendix B for specific information on the definition of protection levels.)

Table A				
Equipment	A	B	C	D
Positive-pressure, self-contained breathing apparatus (SCBA) or pressure demand supplied air respirator with escape SCBA	X	X		
Full-face air purifying respirator			X	
Fully encapsulating gas-tight suit	X			
Chemical resistant clothing (one- or two-piece chemical suits)		X	X	
Coverall (not chemically resistant)				X
Chemical-resistant inner and outer gloves	X	X	X	
Chemical-resistant boots with steel toe	X	X	X	
Two-way radio	X	X	X	
Hard Hat	O	O	O	O
Faceshield		O	O	O
Safety glasses or splash goggles				X
Disposable boot covers	O	O	O	O
Gloves (not chemically resistant)				O
Escape mask		O	O	O
Safety boot (not chemically resistant)				X
X = Required equipment O = Optional				

Suit Material Selection

After the appropriate level of PPE has been determined, the choice of CPC material must be considered. Among the more important factors in selecting the appropriate CPC are chemical resistance and suit design. The effectiveness of the CPC to resist chemicals can be measured by permeation testing.

Permeation is the process by which a chemical moves through a sample of protective clothing material on a molecular level. Permeation testing tells us two things—breakthrough time and permeation rate. Permeation tests are conducted by following the American Society for Testing and Materials (ASTM) F739 “Test Method for Permeation by Liquids and Gases.” Breakthrough time is the time it takes the test chemical to pass from the outside surface of the clothing sample until it is first detected on the inside surface of the clothing sample by an analytical instrument. Permeation rate is the speed at which the test chemical passes through the clothing sample once breakthrough has occurred. The ASTM F739 method only tests a swatch of the actual CPC fabric. This means that the potential for permeation through a zipper, seam, face shield, etc. is not determined. Chemical resistance data is available from many manufacturers and distributors. Unpublished data may be supplied by manufacturers upon request.

Suit design deals with how a garment is put together. Seams are an important aspect of suit design. Two pieces of material can be joined by either stitching or welding.

The stitching process can create pin holes that may allow penetration of chemicals. Welded seams involve cementing or welding tape over the stitched seam. The welded seam offers a higher level of protection against exposure to contaminants.

Choosing a Glove Material

As with CPC, chemical resistance and the physical characteristic of the glove material (refer to Table B) are important. Different glove materials resist different chemicals, so no one glove is suited for all chemical exposures. A glove that is well-suited for one application may prove dangerous for another. Base your glove material selection on the manufacturer’s chemical resistance guide. From the guide, choose a glove that is most resistant to the chemicals being used. Remember, the actual chemical compatibility of a given glove material can vary from manufacturer to manufacturer. Make sure your selection is based on that particular manufacturer’s test data. Another factor to consider is chemical combinations. Glove permeation guides generally list test data for pure chemicals only, not mixtures. In the non-mandatory Appendix B to the Personal Protective Equipment rule 29 CFR 1910 subpart I, OSHA recommends the following for chemical mixtures: *“11(c) For mixtures and formulated products, (unless specific test data are available), a glove should be selected on the basis of the chemical component with the shortest breakthrough time, since it is possible for solvents to carry active ingredients through polymeric materials. For further informa-*

Table B

Material	Abrasion Resistance	Cut Resistance	Flexibility	Heat Resistance	Ozone Resistance	Puncture Resistance	Tear Resistance	Cost
Butyl Rubber	F	G	G	E	E	G	G	High
Natural Rubber	E	E	E	F	P	E	E	Medium
Neoprene	E	E	G	G	E	G	G	Medium
Neoprene/ Styrene-Butadiene Rubber	G	G	G	G	G	G	G	Medium
Neoprene Natural Rubber	E	E	E	G	G	G	G	Medium
Nitrile Rubber	E	E	E	G	F	E	G	Medium
Nitrile/PVC	G	G	G	F	E	G	G	Medium
Polyethylene	F	F	G	F	F	P	F	Low
Chlorinated Polyethylene	E	G	G	G	E	G	G	Low
Polyurethane	E	G	E	G	G	G	G	High
Polyvinyl Alcohol	F	F	P	G	E	F	G	Very High
Polyvinyl Chloride	G	P	F	P	E	G	G	Low
Styrene-Butadiene Rubber	E	G	G	G	F	F	F	Low
Viton	G	G	G	G	E	G	G	Very High

E = Excellent G = Good F = Fair

Table C

	Polycarbonate	Propionate	Acetate
Impact resistance	E	G	G
Water resistance	E	G	F
Weather resistance	G	F	P
Scratch resistance	F	G	G
Acid resistance	G	F	P
Alkaline resistance	G	F	P
Solvent resistance	G	P	F
Heat resistance	E	P	F
Maximum temperature use	250°–280°F	155°–220°F	140°–250°F
E = Excellent G = Good F = Fair			

tion on chemical combinations, check the chemical manufacturer's Material Safety Data Sheet."

Choosing Protective Eyewear

Protective eyewear is available in several styles, sizes and materials. It is very important to match the proper eye protection to your work application (refer to Table C). Goggles offer the most complete protection because they form a seal around the eye area—preventing tiny dust particles, chemical splashes and vapors from irritating the eyes. There are two types of goggles: vented and non-vented (vented can be either indirect or direct).

Non-vented goggles are just that—lenses and frames with no holes for air to seep through. They offer a higher level of protection against vapors and fumes, and can be used to keep harmful vapors out of sensitive eyes. Indirect-vented goggles are "capped" to allow air to move freely in and out without allowing splash or particles in. They offer the same impact protection as the direct-vented goggles. Lens fogging can be a problem because there isn't as much space for the air to move in and out. You may want to consider an anti-fog lens coating to alleviate any potential problems. Direct-vented goggles offer protection from impact only. They fit snugly around the eye area to prevent flying objects from striking your eyes. They also offer more comfort because they allow air to flow in and out to reduce the chance of fogging.

A faceshield (secondary eye protection) may also be needed when exposed to liquid chemical splash, chemical gases or vapors, molten metal or flying particles. Whenever a faceshield is worn, primary protection (goggles or safety glasses) must also be worn. There are no exceptions.

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