Selecting Chemical Protective Clothing for Vapor and Splash Protection

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 and engineering (isolation) and administrative (avoidance) controls should also be considered. In fact, they are required by OSHA under 29 CFR 1910.120 as a preliminary step in limiting worker exposures 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 that a selection can be made that minimizes the risk to the user. For chemical situations, knowing the hazard includes being aware of the type of chemical, the physical state (liquid, solid or gas), and the physiological effect (toxic, carcinogen, asphyxiant, corrosive, etc.). Knowing the level of exposure is also important when selecting protective clothing and equipment.

Level of Risk

To help users choose a total PPE package, EPA's Office of Emergency and Remedial Response has named 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. This type of protection must be gas-tight, vapor-tight and splash resistant. It is worn when there is a possible threat to life and health, such as during spill response and cleanup.

The minimum Level A equipment consists of:

- Positive-pressure, self-contained breathing apparatus (SCBA)
- Gas-tight suit
- Chemical-resistant inner and outer gloves
- Chemical-resistant boots with steel toe and shank

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

The minimum Level B equipment consists of:

- Positive-pressure SCBA
- Chemical-resistant suit
- Chemical-resistant inner and outer gloves
- Chemical-resistant boots with steel toe and shank

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 consists of a normal work uniform (long sleeve coveralls, safety shoes, goggles, etc.), offering minimal protection for nuisance exposure. (See OSHA 29 CFR 1910.120 Appendix B for specific information on the definition of protection levels.)

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 testing produces the following data: breakthrough time and permeation rate. Permeation is the process by which a chemical moves through a sample of protective clothing material on a molecular level. Permeation tests are conducted following the American Society for Testing and Materials (ASTM) F739 test method. The outside surface of a test material is subjected to a challenge chemical using the ASTM F739 test cell. Breakthrough to the inside surface of the material is determined by monitoring the collection side of the test cell and determining when the chemical has permeated.

Breakthrough time is the time it takes the test chemical to pass through the clothing sample until it is first detected 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 are frequently published and 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 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.

NFPA Standards

Developments within the last few years have made the selection of CPC easier for employers. The National Fire Protection Association (NFPA) has devised performance manufacturing standards for CPC.

NFPA 1991, Standard on Vapor-Protective Suits for Hazardous Chemical Emergencies covers gas-tight suits. A suit meeting NFPA 1991 requirements is equal to the clothing required by EPA's Level A.

NFPA 1992, Standard on Liquid Splash-Protective Suits for Hazardous Chemical Emergencies covers splash-protective garments. Garments meeting NFPA 1992 requirements are equal to the clothing required in EPA's Level B.

NFPA 1993, Standard on Support Function Protective Garments for Hazardous Chemical Operations covers splash-protective garments as outlined in NFPA 1992, but states they can be designed for single or limited use.

NFPA developed these standards to provide users with information on suit integrity, resistance to chemicals and flame, durability and function of components. Garments that meet the NFPA requirements are approved and marked with a Safety Equipment Institute (SEI) label.

Sources for More Information

29 CFR 1910.120, Hazardous Waste Operations and Ermergency Response.

29 CFR 1910.120 Appendix B.

Environmental Protection Agency (EPA)
401 M St. SW
Washington, DC 20590
(202) 366-4488

National Fire Protection Association (NFPA)
1 Batterymarch Park
PO Box 9101
Quincy, MA 02269
(617) 770-3000

American Society for Testing Materials (ASTM)
1916 Race St.
Philadelphia, PA 19103
(215) 299-5400

Safety Equipment Institute (SEI)
1901 N. Moore St., Suite 808
Arlington, VA 22209
(703) 525-1695

Works Consulted

1. Anderson, K. J., and J. G. Johnson (eds.), *Chemical Protective Clothing*, Vol. 1, American Industrial Hygiene Association, Akron, OH, 1990.
2. "Focus On Protective Clothing," *Applied Industrial Hygiene*, 4 (1), January 1989, pp. R1–R5.
3. Forsberg, K.; and S. Z. Mansdorf, *Quick Selection Guide To Chemical Protective Clothing*, 1st. ed., Van Nostrand Reinhold, New York, 1989.
4. Roder, M. M., *A Guide for Evaluating the Performance of Chemical Protective Clothing*, National Institute for Occupational Safety and Health, Cincinnati, 1990.
5. Sabatino, J., "Dress For The Party (Selection Of Personal Protective Equipment)," *Environmental Waste Management Magazine*, 8 (6), June 1990, pp. 8–10.
6. Say, D. J., "Chemical Protective Clothing: Still A Long Way To Go," *Fire Engineering*, 114 (8), August 1991, pp. 86–88, 90–92.
7. Schroll, R. C., "Emergency-Response CPC is Last Line of Defense," *Safety & Protective Fabrics*, 2 (2), May 1993, pp. 20–23.
8. "Selecting Personal Protective Equipment," *Hazmat World*, 4 (11), November 1991, pp. 62, 64.
9. Tompkins, N. C., "The Fit Of Chemical Protective Clothing Remains Flexible For Evolving Standards," *Occupational Health & Safety*, 56 (1), January 1994, pp. 46, 48–49.

