Selecting Chemical Protective Clothing for Vapor and Splash Protection – Quick Tips



Although there are no Occupational Safety and Health Administration (OSHA) standards that specifically address chemical protective clothing (CPC), 29 Code of Federal Regulations (CFR) 1910.132 and 1910.120 do apply

1910.132 addresses protective equipment in general, under 1910.132(a) it states:

“Application. Protective equipment, including personal protective equipment for eyes, face, head, and extremities, protective clothing, respiratory devices, and protective shields and barriers, shall be provided, used, and maintained in a sanitary and reliable condition wherever it is necessary by reason of hazards of processes or environment, chemical hazards, radiological hazards, or mechanical irritants encountered in a manner capable of causing injury or impairment in the function of any part of the body through absorption, inhalation or physical contact.”

According to the Hazardous Waste Operations and Emergency Response (HazWoper) standard (29 CFR 1910.120) site-specific safety and health plans must address the safety and health hazards of each site operation and include the elements of protective equipment to be used.

The employer must assess the workplace to determine if hazards are present, or are likely to be present, which necessitate the use of chemical protective clothing (CPC). OSHA mandates that personal protective equipment (PPE) like CPC be used only if the use of engineering controls and/or administrative work practice controls are not feasible or do not reduce employee exposures to acceptable levels. This is known as the OSHA “Three Lines of Defense” philosophy, a commonly used and understood practice within the safety community. For chemical situations, knowing the hazards 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. Since CPC is the last line of defense for protecting the skin, care must be taken to ensure it provides the protection expected.

Protective Equipment Level of Risk

To help users choose a total PPE package, OSHA offers guidance on determining the four levels of chemical risks. These levels are adopted from the Environmental Protection Agency (EPA) and give a range from unknown or highly hazardous, which requires complete protection, to non-hazardous, which requires only basic work attire.

Level A protective equipment 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) or positive pressure supplied air respirator with escape SCBA
- Totally-encapsulating chemical-protective suit
- Chemical-resistant inner and outer gloves
- Chemical-resistant boots with steel toe and shank

See Quick Tips #193: SCBA Information and Quick Tips #191: Chemical Resistant Gloves Guide for more information.

Level B protective equipment offers chemical splash protection, but does not prevent exposure to gases or vapors. As with Level A protective clothing, 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, self-contained breathing apparatus (SCBA) or positive pressure supplied air respirator with escape SCBA
- Hooded chemical-resistant clothing (overalls and long-sleeved jacket; coveralls; one or two-piece chemical-splash suit; disposable chemical-resistant overalls)
- Chemical-resistant inner and outer gloves
- Chemical-resistant boots with steel toe and shank

Level C protective equipment 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 protective equipment 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.

Additional information on the four protection levels is given in OSHA 29 CFR 1910.120 Appendix B.

Chemical Protective Clothing Material Selection

After the appropriate level of PPE has been determined, the choice of CPC material must be considered. The key is identifying the suit material that provides adequate protection against the chemical(s) used. Two important factors in selecting the appropriate CPC are chemical resistance and suit design.

Chemical Resistance

The effectiveness of the CPC to resist chemicals can be measured by permeation testing. Permeation testing produces three important data points:

- Permeation rate is the rate at which the chemical will move through the material. It is measured in a laboratory and is expressed in units of weight of chemical per unit area of material per unit of time, for example milligrams per square meter per second. The higher the permeation rate, the faster the chemical will move through the material. The ASTM F739 method is typically used to determine permeation rate.
- Breakthrough time is the time it takes a chemical to permeate completely through the material. It is determined by applying the chemical on a sample of the clothing material and measuring the time it takes to detect the chemical on the inside surface. The sensitivity of the analytical instruments used in these measurements influence when a chemical is first detected. The breakthrough time gives some indication of how long a clothing material type can be used before the chemical will permeate through the material. ASTM F739 method is also typically used to determine breakthrough time.
- Degradation is a measurement of the physical deterioration of the material due to contact with a chemical. The material may get harder, stiffer, more brittle, softer, weaker, or may swell. The worst outcome is that the material may actually dissolve in the chemical.

The ASTM F739 method only tests a swatch of the actual chemical protective clothing fabric. This means that the potential for permeation through a zipper, seam, face shield, etc. is not determined.

Chemical resistance data is frequently published and available from many manufacturers and distributors. Unpublished data may be supplied by manufacturers upon request.

Suit Design

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 (sealed) seam offers a higher level of protection against exposure to contaminants.

Clothing protection level, chemical resistance and suit design are the primary factors used in selection of CPC, however, other factors that are sometimes overlooked that need to be considered are:

- Know the type of potential contact (e.g., occasional contact or splash protection or continuous immersion). Determine the contact period. How long the worker could be in contact with the chemical(s).
- Consider what hazards may be presented by the use of the protective clothing itself. For example, protective clothing can contribute to heat stress; reduced dexterity; rip or tactile functions; poor comfort; or may contribute to skin conditions.
- Consider the decontamination procedures. Consider whether the CPC should be disposed of or cleaned after use. If they are cleaned, consider the cleaning method, how often they can be cleaned, and any special procedures required for disposing of the "decontamination wash waste"?
- Provide the necessary education and training required which includes:
    - What are the hazards of skin contact with the chemical/material,
    - What are limitations of the protective clothing,
    - What could happen and what to do if the protective clothing fails, and
    - When to dispose of or to decontaminate protective clothing.

NFPA Standards

The National Fire Protection Association (NFPA) has performance manufacturing standards for CPC that aid in its selection.

NFPA 1991 (2016 Edition): Standard on Vapor-Protective Ensembles for

Hazardous Materials Emergencies and CBRN Terrorism Incidents provides requirements for protection for emergency responders against adverse vapor environments during hazardous materials incidents and from specified chemical, biological, or radiological terrorism agents during chemical and biological terrorism incidents. Provisions cover design, performance, labeling, testing, documentation, and certification requirements for new vapor-protective ensembles and ensemble elements. Additional optional criteria for escape protection only from chemical flash fires encountered during hazardous materials incidents are also provided. A suit meeting NFPA 1991 requirements is equal to the clothing required by EPA's Level A.

NFPA 1992 (2012 Edition): Standard on Liquid Splash-Protective Ensembles and Clothing for Hazardous Materials Emergencies provides requirements for protection for emergency responders against adverse liquid splash environments during hazardous materials emergency incidents. Provisions specify design, performance, certification, and documentation requirements; test methods for new liquid splash-protective ensembles and liquid splash-protective clothing. Additional optional criteria for escape protection only from chemical flash fires encountered during hazardous materials incidents are also provided. Garments meeting NFPA 1992 requirements are equal to the clothing required in EPA's Level B.

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.

Selection of CPC is not a simple task. The selection must include a thorough hazard assessment, a methodical review of the needs of the wearers in the field, a thorough familiarity of the chemicals being handled, and an understanding of the information found in manufacturer's chemical databases which includes testing data points such as degradation, permeation, and breakthrough. Other things to consider are availability of the selected items, the manufacturer's willingness to stand behind the product, the reputation of the manufacturer, the distribution system for the products, and of course the price.

Commonly Asked Questions

Q: What is the difference between single-use, limited-use, and reusable chemical protective garments?

A: Single-use garments are intended for one-time wear. Limited-use garments can be worn until they are damaged, altered, or contaminated. Reusable garments can be worn multiple times as long as the suits have

not become damaged during use (or if so, repaired), the suits have been completely decontaminated after use, and the barrier performance of the fabric has not been compromised. Determining whether or not a reusable garment has been fully decontaminated and that the contaminants have not altered the strength or protection capabilities of the garment can be a difficult decision.

Q: Whose responsibility is it to select the appropriate chemical protective clothing?

A: OSHA 29 CFR 1910.132 states that it is the responsibility of the employer to:

- Perform a hazard assessment
- Select PPE and inform employees
- Fit and train employees on use, care, and service life of PPE
- Verify training and audit compliance
- Retrain employees as necessary

Furthermore OSHA states in their Technical Manual, Section VIII, Chapter 1, Chemical Protective Clothing, "Responsibility in selecting appropriate protective clothing should be vested in a specific individual that is trained in both chemical hazards and protective clothing use such as a safety officer or industrial hygienist."

Sources

29 CFR 1910.120, Hazardous Waste Operations and Emergency Response
29 CFR 1910.120 Appendix B
29 CFR 1910.132
OSHA Technical Manual, Section VIII: Chapter 1, Chemical Protective Clothing
DuPont information on Industry Methods, Standards & Regulations
DuPont Safespec chemical testing database
Lakeland Chemax chemical testing database
Kappler Hazmatch chemical protective clothing selection guide
National Fire Protection Association (NFPA)
ASTM International (ASTM)
Safety Equipment Institute (SEI)
Daniel H. Anna, Chemical Protective Clothing, Second Edition, American Industrial Hygiene Association (AIHA), 2003
National Institute of Occupational Safety and Health (NIOSH), Recommendations for Chemical Protective Clothing database.
Roder, M. M., A Guide for Evaluating the Performance of Chemical Protective Clothing, National Institute for Occupational Safety and Health, Cincinnati, 1990.
Krister Forsberg, Ann Van den Borre, Norman Henry, II and James P. Zeigler, Quick Selection Guide to Chemical Protective Clothing, Wiley, sixth edition, 2014.
National Environmental Trainers, Selection of Chemical Protective

Clothing, blog posting.

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