Mission-Specific Competencies: Personal Protective Equipment

CHAPTER 7

NFPA 472 Standard

Competencies for Operations Level Responders Assigned Mission-Specific Responsibilities

6.1 General.

6.1.1 Introduction.

6.1.1.1 This chapter shall address competencies for the following operations level responders assigned mission-specific responsibilities at hazardous materials/WMD incidents by the authority having jurisdiction beyond the core competencies at the operations level (Chapter 5):

(1) Operations level responders assigned to use personal protective equipment [p. 159–179]

(2) Operations level responders assigned to perform mass decontamination

(3) Operations level responders assigned to perform technical decontamination

(4) Operations level responders assigned to perform evidence preservation and sampling

(5) Operations level responders assigned to perform product control

(6) Operations level responders assigned to perform air monitoring and sampling

(7) Operations level responders assigned to perform victim rescue/recovery

(8) Operations level responders assigned to respond to illicit laboratory incidents

6.1.1.2 The operations level responder who is assigned mission-specific responsibilities at hazardous materials/WMD incidents shall be trained to meet all competencies at the awareness level (Chapter 4), all core competencies at the operations level (Chapter 5), and all competencies for the assigned responsibilities in the applicable section(s) in this chapter. [p. 159–179]

6.1.1.3 The operations level responder who is assigned mission-specific responsibilities at hazardous materials/WMD incidents shall receive additional training to meet applicable governmental occupational health and safety regulations. [p. 159–179]

6.1.1.4 The operations level responder who is assigned mission-specific responsibilities at hazardous materials/WMD incidents shall operate under the guidance of a hazardous materials technician, an allied professional, an emergency response plan, or standard operating procedures. [p. 159–179]

6.1.1.5 The development of assigned mission-specific knowledge and skills shall be based on the tools, equipment, and procedures provided by the AHJ for the mission-specific responsibilities assigned. [p. 159–179]

6.1.2 Goal. The goal of the competencies in this chapter shall be to provide the operations level responder assigned mission-specific responsibilities at hazardous materials/WMD incidents by the AHJ with the knowledge and skills to perform the assigned mission-specific responsibilities safely and effectively. [p. 159–179]

6.1.3 Mandating of Competencies. This standard shall not mandate that the response organizations perform mission-specific responsibilities. [p. 159–179]

6.1.3.1 Operations level responders assigned mission-specific responsibilities at hazardous materials/WMD incidents, operating within the scope of their training in this chapter, shall be able to perform their assigned mission-specific responsibilities. [p. 159–179]

6.1.3.2 If a response organization desires to train some or all of its operations level responders to perform mission-specific responsibilities at hazardous materials/WMD incidents, the minimum required competencies shall be as set out in this chapter. [p. 159–179]

6.2 Mission-Specific Competencies: Personal Protective Equipment.

6.2.1 General.

6.2.1.1 Introduction.

6.2.1.1.1 The operations level responder assigned to use personal protective equipment shall be that person, competent at the operations level, who is assigned to use of personal protective equipment at hazardous materials/WMD incidents. [p. 159–179]

6.2.1.1.2 The operations level responder assigned to use personal protective equipment at hazardous materials/WMD incidents shall be trained to meet all competencies at the awareness level (Chapter 4), all core competencies at the operations level (Chapter 5), and all competencies in this section. [p. 159–179]

6.2.1.1.3 The operations level responder assigned to use personal protective equipment at hazardous materials/WMD incidents shall operate under the guidance of a hazardous materials technician, an allied professional, or standard operating procedures. [p. 159–179]

6.2.1.1.4 The operations level responder assigned to use personal protective equipment shall receive additional training necessary to meet specific needs of the jurisdiction. [p. 159–179]

6.2.1.2 Goal. The goal of the competencies in this section shall be to provide the operations level responder assigned to use personal protective equipment with the knowledge and skills to perform the following tasks safely and effectively:

(1) Plan a response within the capabilities of personal protective equipment provided by the AHJ in order to perform mission specific tasks assigned. [p. 159–179]

(2) Implement the planned response consistent with the standard operating procedures and site safety and control plan by donning, working in, and doffing personal protective equipment provided by the AHJ. [p. 159–179]

(3) Terminate the incident by completing the reports and documentation pertaining to personal protective equipment. [p. 179]

6.2.3 Competencies—Planning the Response.

6.2.3.1 Selecting Personal Protective Equipment. Given scenarios involving hazardous materials/WMD incidents with known and unknown hazardous materials/WMD, the operations level responder assigned to use personal protective equipment shall select the personal protective equipment required to support mission-specific tasks at hazardous materials/WMD incidents based on local procedures and shall meet the following requirements:

(1) Describe the types of protective clothing and equipment that are available for response based on NFPA standards and how these items relate to the EPA levels of protection. [p. 161–174]

(2) Describe personal protective equipment options for the following hazards:

- (a) Thermal [p. 161–162, 165–167]
- (b) Radiological [p. 161–162, 164]
- (c) Asphyxiating [p. 162, 164–167]
- (d) Chemical [p. 162–174]
- (e) Etiological/biological [p. 162, 164–165]
- (f) Mechanical [p. 161–162, 167]

(3) Select personal protective equipment for mission-specific tasks at hazardous materials/WMD incidents based on local procedures.

- (a) Describe the following terms and explain their impact and significance on the selection of chemical-protective clothing:
  - i. Degradation [p. 163]
  - ii. Penetration [p. 162–163]
  - iii. Permeation [p. 163]
- (b) Identify at least three indications of material degradation of chemical-protective clothing. [p. 163]
- (c) Identify the different designs of vapor-protective and splash-protective clothing and describe the advantages and disadvantages of each type. [p. 163–164]
- (d) Identify the relative advantages and disadvantages of the following heat exchange units used for the cooling of personnel operating in personal protective equipment:
  - i. Air cooled [p. 178]
  - ii. Ice cooled [p. 178]
  - iii. Water cooled [p. 179]
  - iv. Phase change cooling technology [p. 179]
- (e) Identify the physiological and psychological stresses that can affect users of personal protective equipment. [p. 175–178]
- (f) Describe local procedures for going through the technical decontamination process. [p. 159]

6.2.4 Competencies—Implementing the Planned Response.

6.2.4.1 Using Protective Clothing and Respiratory Protection. Given the personal protective equipment provided by the AHJ, the operations level responder assigned to use personal protective equipment shall demonstrate the ability to don, work in, and doff the equipment provided to support mission-specific tasks and shall meet the following requirements:

(1) Describe at least three safety procedures for personnel wearing protective clothing. [p. 174–178]

(2) Describe at least three emergency procedures for personnel wearing protective clothing. [p. 162–163]

(3) Demonstrate the ability to don, work in, and doff personal protective equipment provided by the AHJ. [p. 165–174]

(4) Demonstrate local procedures for responders undergoing the technical decontamination process. [p. 159]

(5) Describe the maintenance, testing, inspection, storage, and documentation procedures for personal protective equipment provided by the AHJ according to the manufacturer's specifications and recommendations. [p. 159–179]

6.2.5 Competencies—Terminating the Incident.

6.2.5.1 Reporting and Documenting the Incident. Given a scenario involving a hazardous materials/WMD incident, the operations level responder assigned to use personal protective equipment shall identify and complete the reporting and documentation requirements consistent with the emergency response plan or standard operating procedures regarding personal protective equipment. [p. 179]

Knowledge Objectives

After studying this chapter, you will be able to:

- Describe personal protective equipment (PPE) used for hazardous materials incidents.
- Describe the capabilities of the PPE provided by the authority having jurisdiction (AHJ) so as to perform any mission-specific tasks assigned.
- Describe how to don, work in, and doff the PPE provided by the AHJ.
- Describe performance requirements of PPE.
- Describe ways to ensure that personnel do not go beyond their level of training and equipment.
- Describe cooling technologies.
- Terminate the incident by completing the reports and documentation pertaining to PPE.

Skills Objectives

After studying this chapter, you will be able to:

- Demonstrate the ability to properly don and doff a Level A ensemble.
- Demonstrate the ability to properly don and doff a Level B nonencapsulating chemical-protective clothing ensemble.
- Demonstrate the ability to properly don and doff a Level C chemical-protective clothing ensemble.
- Demonstrate the ability to properly don and doff a Level D chemical-protective clothing ensemble.

You Are the Responder

Your engine company arrives on the scene of a vehicle accident involving a small passenger vehicle and a tanker truck carrying 20 tons of anhydrous ammonia. The tanker rolled over on its side as a result of the accident and slid down the highway for approximately 100 feet. There are no injuries to the three victims in the passenger vehicle, but the driver of the tanker truck is pinned inside the cab. You notice the smell of ammonia in the air but see no visible signs of a product release. The regional hazardous materials team, fully staffed with technician level responders, is also on scene. Your company officer confers with the hazardous materials team and then directs you and another fire fighter to don your SCBA and full turnout gear and evaluate the driver for injuries.

1. Would full structural fire fighter's turnout gear and SCBA offer adequate protection in this situation?
2. Based on your level of training—operations level core competencies and all of the mission-specific competencies—would you be qualified to perform this task?
3. Describe the steps you would need to take, including obtaining information about ammonia, to complete your assignment.

Introduction

In all situations involving hazardous materials, it is important for responders to understand the nature of the release and to have all the tools and equipment required to safely complete the task at hand. Using a risk-based approach is important to the success of the response, and emergency responders should be familiar with the policies and procedures of the local jurisdiction to ensure a consistent approach to selecting the proper personal protective equipment (PPE). Additionally, all responders charged with responding to hazardous materials/weapons of mass destruction (WMD) incidents should be proficient with local procedures for technical decontamination as well as the manufacturers' guidelines for maintenance, testing, inspection, storage, and documentation procedures for the PPE provided by the AHJ. Refer to Chapter 4 of this text for the specifics of the NFPA standards on protective clothing and specific information on the Occupational Safety and Health Administration (OSHA)/ Environmental Protection Agency (EPA) levels of protection.

This chapter contains several skill drills and suggestions on recommended methods to don and doff the various levels of PPE, and it emphasizes some of the safety considerations that should be factored in whenever personnel are wearing PPE.

Much of the chemical-protective equipment (PPE) on the market today is intended for a single use or limited use (i.e., it is disposable), and is expected to be discarded along with the other hazardous waste generated by the incident. As a consequence of this intention, limited-use PPE is decontaminated to the point it is safe for the responder to remove, but not so extensively that the garment is completely free of contamination. Limited-use PPE is generally less expensive than reusable gear, and it needs to be restocked and/or replenished after the incident. Before the use of this equipment, these items require a thorough visual inspection to ensure they are response ready. They typically have a shelf life.

Reusable garments are required to be tested at regular intervals (usually annually) and after each use. Individual manufacturers will have well-defined procedures for this activity. Prior to purchasing any type of PPE, the AHJ should understand what will be required in terms of its maintenance and upkeep. Level A suits, for example, are required to be pressure tested—usually upon receipt from the manufacturer, after each use, and annually Figure 7-1 ▸.

Chemical-protective garments are tested in accordance with the manufacturer's recommendation or following the method outlined in the OSHA's HAZWOPER standard (29 CFR 1910.120 Appendix A). Generally speaking, the test is accomplished by using a pressure test kit to pump a certain amount of air into the suit and then leaving the suit pressurized for a specified period of time. At that point, if the garment has lost more than a certain percentage (usually 20 percent) of

Figure 7-1 A suit testing kit.

Responder Safety Tips

TRACEMP is common acronym used to sum up a collection of potential hazards that an emergency responder may face.

- Thermal
- Radiological
- Asphyxiating
- Chemical
- Etiological/biological
- Mechanical
- Psychogenic

pressure, it is assumed the suit has a leak. Oftentimes, leaks are located by gently spraying or brushing the inflated suit with a solution of soapy water. Small bubbles begin to form in the area of the leak, alerting you to the presence of a leak. Any garment with a leak should be removed from service until the defect is identified and repaired in accordance with the manufacturer's specification.

Chemical-protective equipment should be stored in a cool, dry place that is not subject to significant temperature extremes and/or high levels of humidity. Furthermore, the equipment should be kept in a clean location, away from direct sunlight, and should be inspected at regular intervals based on the manufacturer's recommendations. If repairs are required, consult the manufacturer prior to performing any work—there is a risk that the garment will not perform as expected if it has been modified or repaired incorrectly. Again, individual manufacturers have well-defined procedures for this activity and prior to purchasing any PPE, the AHJ should understand what will be required in terms of maintenance and upkeep.

As the title of this chapter (Mission-Specific Competencies: Personal Protective Equipment) implies, responders must correlate the mission they are expected to perform with the anticipated hazards. For example, in the ammonia scenario described earlier, the responders should understand that ammonia presents a significant health hazard because it is corrosive to the skin, eyes, and lungs. Ammonia is also flammable at concentrations of approximately 15 to 25 percent (by volume) in a mixture with air. Exposure to a concentration of approximately 300 parts per million (ppm) is considered to be immediately dangerous to life and health (IDLH). If the possibility of exposure to concentration exceeding 300 ppm exists, a **National Institute for Occupational Safety and Health (NIOSH)** approved **self-contained breathing apparatus (SCBA)** is required. NIOSH sets the design, testing, and certification requirements for SCBA in the United States.

Although SCBA will protect the responders from suffering an inhalation exposure, its use is only one piece of the equipment equation. Another question must be answered in this scenario: Will structural fire fighter's turnout gear provide sufficient skin protection? Knowing that ammonia presents a flammability hazard is important—and the turnout gear would address that potential—but that choice of equipment still does not address the hazard of skin irritation.

The responders tasked with undertaking a medical reconnaissance mission in the ammonia scenario should balance these hazards and the risk of the mission with the potential gain. This scenario is based on an outdoor release, with unknown variables of wind speed and ambient temperatures, which may positively or negatively influence the decision to approach the cab of the truck. Unfortunately, it is impossible to decide on the right course of action based on a few sentences in this book—you must make that decision on the street, at the moment the emergency occurs. Part of your thinking must take into account the age and condition of your turnout gear. Unfortunately, not all structural fire fighter's gear is created equal, and not all equipment is intended to function in an environment that may contain a hazardous material. Structural fire fighter's gear that is 10 years old will certainly not provide the same level of protection as an ensemble that meets the certification requirements for the 2007 edition of the National Fire Protection Association (NFPA) 1971, *Standard on Protective Ensembles for Structural Fire Fighting and Proximity Fire Fighting.*

The nature of emergency response today is different than it was 10 years ago, especially when it comes to PPE. The potential hazards are more complex and perhaps less obvious than they once were, and you may find yourself past the point of no return within a very short amount of time. To that end, it is incumbent on every emergency responder to understand the hazards that may be present on an emergency scene, and to appreciate how those hazards may affect the mission the responders are tasked with carrying out.

TRACEMP is an acronym often used to sum up a collection of potential hazards that an emergency responder may face:

Thermal
Radiological
Asphyxiating
Chemical
Etiological/biological
Mechanical
Psychogenic

Hazardous Materials: Specific Personal Protective Equipment

As discussed in Chapter 4, different levels of PPE may be required at different hazardous materials incidents. This section reviews the protective qualities of various ensembles, from those offering the least protection to those providing the greatest protection.

At the lowest end of the spectrum are street clothing and normal work uniforms, which offer the least amount of protection in a hazardous materials emergency. Normal clothing may prevent a noncaustic powder from coming into direct contact with the skin, for example, but it offers no significant protection against many other hazardous materials. A one-piece flame-resistant coverall may enhance protection slightly. Such PPE is often used in industrial applications such as oil refineries, as a general work uniform **Figure 7-2**. Police officers, emergency medical services providers, and public works employees typically wear this level of "protection." In terms of the threats outlined in TRACEMP, this level of clothing offers very little in the way of chemical protection. Most often, distance from the hazard is the best level of protection with this PPE—that's why you will see it worn almost exclusively in the cold zone.

The next level of protection is provided by structural firefighting protective equipment **Figure 7-3**. Such an outfit includes a helmet, a bunker coat, bunker pants, boots, gloves, a hood, SCBA, and a personal alert safety system (PASS) device. Standard firefighting turnout gear offers little chemical protection, although it does have a high degree of abrasion resistance and prevents direct skin contact. However, the fabric may break down when exposed to chemicals, and it does not provide complete protection from the harmful gases, vapors, liquids, and dusts that could be encountered during hazardous materials incidents.

Returning to the ammonia scenario, it may be safe and reasonable to carry out the patient assessment mission wearing this level of protection—again, based on a full risk assessment. Keep in mind that structural fire fighter's gear is primarily intended to address thermal (hot and cold) and mechanical hazards. The same gear may be called upon for other reasons, such as for protecting the wearer protection against alpha and beta radiation, but that is not its primary function.

Recall that alpha particles have weight and mass and, therefore, cannot travel very far (less than a few centimeters) from the nucleus of the atom. For the purpose of comparison, alpha particles are like dust particles. Typical alpha emitters include americium (found in smoke detectors), polonium (identified in cigarette smoke), radium, radon, thorium, and uranium. You can protect yourself from alpha emitters by staying several feet away from their source and by protecting your respiratory tract with either a HEPA filter on a simple respirator or SCBA. **High-efficiency particulate air (HEPA) filters** catch particles down to 0.3-micron size—much smaller than a typical dust particle or anthrax spore.

By comparison, beta particles are more energetic than alpha particles and, therefore, pose a greater health hazard. Es-

Figure 7-2 A Nomex jumpsuit.

Figure 7-3 Standard turnout gear or structural firefighting gear.

sentially, beta particles are like electrons, except that a beta particle is ejected from the nucleus of an unstable atom. Depending on the strength of the source, beta particles can travel several feet in the open air. Beta particles themselves are not radioactive; the radiation energy is generated by the speed at which the particles are emitted from the nucleus.

Gamma radiation is so strong that structural fire fighter's gear and/or any chemical-protective clothing will offer no significant level of protection from this threat. Time, distance, and shielding are the preferred method of protection when high levels of radiation are present.

Structural fire fighter's gear protects against asphyxiants such as nitrogen and helium (when used in conjunction with SCBA) and selected biological agents such as anthrax (when used in conjunction with SCBA or appropriate HEPA filtration on an **air-purifying respirator [APR]** or **powered air-purifying respirator [PAPR]**). The gear may not be able to be decontaminated after this type of exposure, but it may protect the wearer enough to prevent harm.

Unusually high thermal hazards, such as those posed by aircraft fires, may best be addressed by responders wearing **high temperature–protective equipment**. This type of PPE shields the wearer during short-term exposures to high temperatures Figure 7-4. Sometimes referred to as a proximity suit, high temperature–protective equipment allows the properly trained fire fighter to work in extreme fire conditions. It provides protection against high temperatures only, however; it is not designed to protect the fire fighter from hazardous materials.

Chemical-Protective Clothing and Equipment

Chemical-protective clothing is unique in that it is designed to prevent chemicals from coming in contact with the body. Such equipment is not intended to provide high levels of protection from thermal hazards (heat and cold) or to protect the wearer from injuries that may result from torn fabric, chemical damage, or other mechanical damage to the suit. Not all chemical-protective clothing is the same, and each type, brand, and style may offer varying degrees of resistance.

To help you safely estimate the chemical resistance of a particular garment, manufacturers supply compatibility charts with all of their protective equipment Figure 7-5. These charts are intended to assist you in choosing the right chemical-protective clothing for the incident at hand. You must match the anticipated chemical hazard to these charts to determine the resistance characteristics of the garment.

Time, temperature, and resistance to cuts, tears and abrasions are all factors that affect the chemical resistance of materials. Other factors include flexibility, shelf life, and sizing criteria. The bottom line is that **chemical-resistant materials** are specifically designed to inhibit or resist the passage of chemicals into and through the material by the processes of penetration, permeation, or degradation.

Penetration is the flow or movement of a hazardous chemical through closures such as zippers, seams, porous materials, pinholes, or other imperfections in the material. To reduce the threat of a penetration-related suit failure, responders

Figure 7-4 High temperature–protective equipment protects the wearer from high temperatures during a short exposure.

Figure 7-5 An example of a compatibility chart supplied with personal protective equipment.

should carefully evaluate their PPE prior to entering a contaminated atmosphere. Checking the garment fully—that is, performing a visual inspection of all its components—before donning the PPE is paramount. Just because the suit or gloves came out of a sealed package does not mean they are perfect! Also, a lack of attention to detail could result in zippers not being fully closed and tight. Poorly fit seams around ankles and wrists could allow chemicals to defeat the integrity of the garment. Use of the buddy system is beneficial in this setting because it creates the opportunity to have a trained set of eyes examine parts of the suit that the wearer cannot see. Prior to entering a contaminated atmosphere, or periodically while working, each member of the entry team should quickly scan the PPE of the other member(s) to see if anyone's suit has suffered any damage, discoloration, or other insult that may jeopardize the health and safety of the wearer.

Permeation is the process by which a hazardous chemical moves through a given material on the molecular level. It differs from penetration in that permeation occurs through the material itself rather than through openings in the material. Permeation may be impossible to identify visually, but it is important to note the initial status of the garment and to determine if any changes have occurred (or are occurring) during the course of an incident. Chemical compatibility charts are based on two properties of the material: its breakthrough time (how long it takes a chemical substance to be absorbed into the suit fabric and detected on the other side) and the permeation rate (how much of the chemical substance makes it through the material) Figure 7-6. The concept is similar to water saturating a sponge. When evaluating the effectiveness of a particular material against a given substance, responders should look for the longest breakthrough time available. For example, a good breakthrough time would be more than 480 minutes—a typical 8-hour workday.

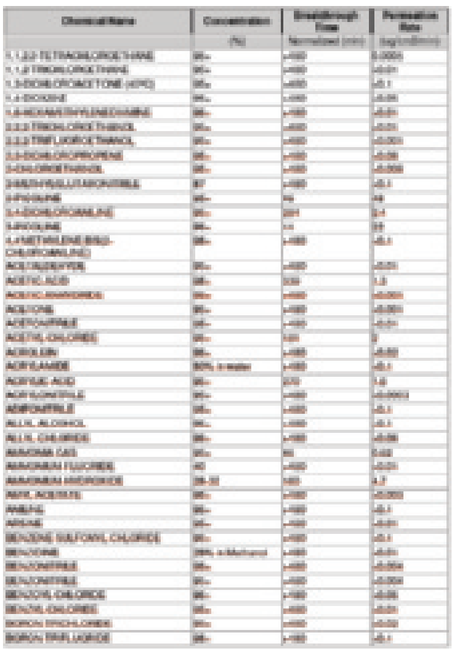

Figure 7-6 Breakthrough time is the time it takes a chemical substance to be absorbed into the suit fabric and detected on the other side.

Degradation is the physical destruction or decomposition of a clothing material owing to chemical exposure, general use, or ambient conditions (e.g., storage in sunlight). It may be evidenced by visible signs such as charring, shrinking, swelling, color changes, or dissolving. Materials can also be tested for weight changes, loss of fabric tensile strength, and other properties to measure degradation. Think about the rapid and destructive way in which gasoline dissolves a Styrofoam cup. When chemicals are so aggressive, or when the suit fabric is a poor match for the suspect substance, degradation is possible. If the suit dissolves, the possibility of the wearer suffering an injury is high.

Chemical-protective clothing can be constructed as a single- or multi-piece garment. A single-piece garment completely encloses the wearer and is known as an encapsulated suit. A multi-piece garment typically has a jacket, pants, an attached or detachable hood, gloves, and boots to protect against a specific hazard. Ensembles worn as Level B and Level C protection are commonly comprised of multi-piece garments.

Chemical-protective clothing—both single- and multi-piece—are classified into two major categories: vapor-protective clothing and liquid splash–protective clothing. Both are described following this section. Many different types of materials are manufactured for both categories; it is the AHJ's responsibility to determine which type of suit is appropriate for its situation. Be aware that no single chemical-protective garment (vapor or splash) on the market will protect you from everything.

Vapor-protective clothing, also referred to as fully encapsulating protective clothing, offers full body protection from highly contaminated environments and requires the wearer to use an air-supplied respiratory device such as SCBA Figure 7-7. The wearer is completely zipped inside the protective "envelope," leaving no skin (or the lungs) accessible to the outside. If the ammonia scenario described at the beginning of the chapter were occurring in a different location—such as inside a poorly ventilated storage area within an ice-making facility—vapor-protective clothing might be required. Ammonia aggressively attacks skin, eyes, and mucous membranes such as the eyes and mouth and can cause severe and irreparable damage to the lungs. Hydrogen cyanide would be another example of a chemical substance that would require this level of protection. Hydrogen cyanide can be fatal if inhaled or absorbed through the skin, so the use of a fully encapsulating suit is required to adequately protect the wearer. NFPA 1991, *Standard on Vapor-Protective Ensembles for Hazardous Materials Emergencies,* sets the performance standards for vapor-protective garments.

Liquid splash–protective clothing is designed to protect the wearer from chemical splashes Figure 7-8. NFPA 1992, *Standard on Liquid Splash-Protective Ensembles and Clothing for Hazardous Materials Emergencies,* is the performance document that governs liquid splash–protective garments and ensembles. Equipment that meets this standard has been tested for

Figure 7-7 Vapor-protective clothing retains body heat, so it also increases the possibility of heat-related emergencies among responders.

Figure 7-8 Liquid splash–protective clothing must be worn whenever there is the danger of chemical splashes.

penetration against a battery of five chemicals. The tests include no gases, as this level of protection is not considered to be vapor protection.

Responders may choose to wear liquid splash–protective clothing based on the anticipated hazard posed by a particular substance. As you learned in Chapter 4, liquid splash–protective clothing does not provide total body protection from gases or vapors, and it should not be used for incidents involving liquids that emit vapors known to affect or be absorbed through the skin. This level of protection may consist of several pieces of clothing and equipment designed to protect the skin and eyes from chemical splashes. Some agencies, depending on the situation, choose to have their personnel wear liquid splash protection over or under structural firefighting clothing.

Responders trained to the operational level often wear liquid splash–protective clothing when they are assigned to enter the initial site, perform decontamination, or construct isolation barriers such as dikes, diversions, retention areas, or dams.

Respiratory Protection

NFPA 1994, *Standard on Protective Ensembles for First Responders to CBRN (Chemical, Biological, Radiological, and Nuclear) Terrorism Incidents,* was developed to address the performance of protective ensembles and garments (including respiratory protection) specific to weapons of mass destruction. NFPA 1994 covers three classes of equipment: Class 2, Class 3, and Class 4. As discussed in Chapter 4 and later in this chapter, the EPA and the OSHA HAZWOPER regulations classify ensemble levels as Level A, Level B, Level C, and Level D. The main difference between their system and the NFPA 1994 classification is that NFPA 1994 covers the performance of the garment *and* factors in the performance of the respiratory protection.

Simple asphyxiants such as nitrogen, argon, and helium, as well as oxygen-deficient atmospheres, are best handled by using a SCBA or another **supplied-air respirator (SAR)**. SCBA units that comply with the current version of NFPA 1981, *Standard on Open-Circuit Self-Contained Breathing Apparatus (SCBA) for Emergency Services,* are positive-pressure, CBRN-certified units that maintain a pressure inside the face piece, in relation to the pressure outside the face piece, such that the pressure is positive during both inhalation and exhalation. This is a very important feature when operating in airborne contamination.

The most common types of SCBA are referred to as 30-minute and 60-minute units. The time designation refers to the optimal amount of work time available when the unit is fully charged. Actual work times are generally less than the 30-minute and 60-minute designations, but will vary depending on the wearer's underlying physical condition and respiratory rate, workload, travel time to and from the incident site, decontamination, and other environmental factors.

The extra weight and reduced visibility associated with this equipment are factors to consider when choosing to wear an SCBA. As with any piece of PPE, there are as many positive benefits as there are negative points to consider in making this decision. Any responder called upon to wear an SCBA should be fully trained by the AHJ prior to operating in a contaminated environment. The OSHA HAZWOPER standard states that all employees engaged in emergency response who are exposed to hazardous substances *shall* wear a positive-pressure SCBA. Furthermore, the incident commander (IC) is *required* to ensure the use of SCBA. It is not just a good idea—it's the law. Additionally, all responders should follow manufacturers' recommendations for using, maintaining, testing, inspecting, cleaning, and filling the SCBA unit. Be sure to document all of these activities so there is a record of what has been done to the unit. Refer back to Chapter 4 for more information about the various types of respiratory protection.

Chemical-Protective Clothing Ratings

A variety of fabrics are used in both vapor-protective and liquid splash–protective garments and ensembles. Commonly used suit fabrics include butyl rubber, Tyvek, Saranex, polyvinyl chloride (PVC), and Viton. Protective clothing materials must be compatible with the chemical substances involved, and the garments should be used within the parameters set by their manufacturer. The manufacturer's guidelines and recommendations should be consulted for material compatibility information.

The following EPA guidelines may be used by a responder to assist in determining the appropriate level of protection for a particular hazard. The procedures for the **donning** and **doffing** of equipment are also described in the following sections.

Level A

A **Level A ensemble** consists of a fully encapsulating garment that completely envelops both the wearer and his or her respiratory protection Figure 7-9. Level A equipment should be used when the hazardous material identified requires the highest level of protection for skin, eyes, and lungs. Such an ensemble is effective against vapors, gases, mists, and dusts and is typically indicated when the operating environment exceeds IDLH values for skin absorption.

Level A protection, when worn in accordance with NFPA 1991, *Standard on Vapor-Protective Ensembles for Hazardous Materials Emergencies,* will protect the wearer only against very brief flash fire. To that end, thermal extremes should be approached with caution. Direct contact between the suit fabric and a cryogenic material, such as liquid nitrogen or liquid helium, may result in immediate suit failure. This type of ensemble more than addresses the asphyxiant threat—it's the temperature extreme that must be acknowledged. By contrast, a potentially explosive atmosphere should be considered an extremely dangerous situation. In such circumstances, Level A suits, even with the flash fire component of the suit in place, provide very limited protection. Moreover, it is difficult to see when wearing a Level A suit, which increases the possibility that the person may unknowingly bump into sharp objects that might puncture the suit's vapor-protective environment. Therefore, some forethought about the operating environment should occur well before entering the contaminated atmosphere. As always, a risk-versus-reward thought process should prevail.

Level A protection is effective against alpha radiation, but because of the lack of fabric thickness (as compared to fire fighter's turnout gear) it may not offer adequate protection against beta radiation. Remember—thorough detection and monitoring actions will help you determine the nature of the operating environment.

Figure 7-9 A Level A ensemble envelops the wearer in a totally encapsulating suit.

Ensembles worn as Level A protection must meet the requirements outlined in NFPA 1991. A Level A ensemble also requires open-circuit, positive-pressure SCBA or an SAR for respiratory protection. Chapter 4 of this text provides a list of the recommended and optional components of Level A protection.

To don a Level A ensemble, follow the steps in Skill Drill 7-1:

1. Conduct a pre-entry briefing, medical monitoring, and equipment inspection. (Step 1)
2. While seated, pull on the suit to waist level and pull on the attached chemical boots. Fold the suit boot covers over the tops of the boots. (Step 2)
3. Stand up and don the SCBA frame and SCBA face piece, but do not connect the regulator to the face piece. (Step 3)
4. Place the helmet on the head. (Step 4)
5. Don the inner gloves. (Step 5)
6. Don the outer chemical gloves (if required by the manufacturer's specifications).
7. With assistance, complete donning the suit by placing both arms in the suit, pulling the expanded back piece over the SCBA, and placing the chemical suit over the head. (Step 6)

NFPA 472, 6.2.4.1

Skill Drill 7-1

Donning a Level A Ensemble

1 Conduct a pre-entry briefing, medical monitoring, and equipment inspection.

2 While seated, pull on the suit to waist level; pull on the chemical boots over the top of the chemical suit. Pull the suit boot covers over the tops of the boots.

3 Stand up and don the SCBA frame and SCBA face piece, but do not connect the regulator to the face piece.

4 Place the helmet on the head.

5 Don the inner gloves.

6 Don the outer chemical gloves (if required). With assistance, complete donning the suit by placing both arms in the suit, pulling the expanded back piece over the SCBA, and placing the chemical suit over the head.

7 Instruct the assistant to connect the regulator to the SCBA face piece and ensure air flow.

8 Instruct the assistant to close the chemical suit by closing the zipper and sealing the splash flap.

9 Review hand signals and indicate that you are okay.

8. Instruct the assistant to connect the regulator to the SCBA face piece and ensure that the air flow is working correctly. (Step 7)
9. Instruct the assistant to close the chemical suit by closing the zipper and sealing the splash flap. (Step 8)
10. Review hand signals and indicate that you are okay. (Step 9)

To doff a Level A ensemble, follow the steps in Skill Drill 7-2:

1. After completing decontamination, proceed to the clean area for suit doffing.
2. Pull the hands out of the outer gloves and arms from the sleeves, and cross the arms in front inside the suit. (Step 1)
3. Instruct the assistant to open the chemical splash flap and suit zipper. (Step 2)
4. Instruct the assistant to begin at the head and roll the suit down and away until the suit is below waist level. (Step 3)
5. Instruct the assistant to complete rolling the suit from the waist to the ankles; step out of the attached chemical boots and suit. (Step 4)
6. Doff the SCBA frame. The face piece should be kept in place while the SCBA is doffed. (Step 5)
7. Take a deep breath and doff the SCBA face piece; carefully remove the helmet, peel off the inner gloves, and walk away from the clean area.
8. Go to the rehabilitation area for medical monitoring, rehydration, and personal decontamination shower. (Step 6)

Figure 7-10 A Level B protective ensemble provides a high level of respiratory protection but less skin protection.

Level B

A **Level B ensemble** consists of multi-piece chemical-protective clothing, boots, gloves, and SCBA Figure 7-10. This type of protective ensemble should be used when the type and atmospheric concentration of identified substances require a high level of respiratory protection but less skin protection. The kinds of gloves and boots worn depend on the identified chemical.

The Level B protective ensemble is the workhorse of hazardous materials response—it is a very common level of protection and is often chosen for its versatility. Such an ensemble is commonly worn by personnel initially processing a clandestine drug laboratory, performing preliminary missions for reconnaissance, or engaging in detection and monitoring duties. The typical Level B ensemble provides little or no flash fire protection, however. Thus it should be viewed in the same manner as Level A equipment when it comes to thermal protection and other considerations of use such as protection from mechanical hazards, radiation, or asphyxiants.

Garments and ensembles that are worn for Level B protection should comply with the performance requirements found in NFPA 1992, *Standard on Liquid Splash-Protective Ensembles and Clothing for Hazardous Materials Emergencies*. Chapter 4 of this text provides a list of the recommended and optional components of a Level B protective ensemble.

You may also encounter single piece garments that are worn as level B protection. These suits, referred to in the field as encapsulating Level B garments, are not constructed to be "vapor tight" like Level A garments. Encapsulating Level B garments do not have vapor tight zippers, seams, or one-way relief valves around the hood like Level A garments. Although the encapsulating Level B suit may look a lot like a Level A garment, it is not constructed similarly, and will not offer the same level of protection.

To don and doff a Level B encapsulated chemical-protective clothing ensemble, follow the same steps found in Skill Drills 7-1 and 7-2. Remember, the difference between the Level A ensemble and Level B encapsulating ensemble is not the procedure—it is the construction and performance of the garment.

Responder Safety Tips

According to the OSHA HAZWOPER regulation, Level B is the minimum level of protection to be worn when operating in an unknown environment.

Skill Drill 7-2

NFPA, 472, 6.2.4.1

Doffing a Level A Ensemble

1 After completing decontamination, proceed to the clean area for suit doffing. Pull the hands out of the outer gloves and arms from the sleeves, and cross the arms in front inside the suit.

2 Instruct the assistant to open the chemical splash flap and suit zipper.

3 Instruct the assistant to begin at the head and roll the suit down and away until the suit is below waist level.

4 Instruct the assistant to complete rolling the suit from the waist to the ankles; step out of the attached chemical boots and suit.

5 Doff the SCBA frame. The face piece should be kept in place while the SCBA frame is doffed.

6 Take a deep breath and doff the SCBA face piece; carefully peel off the inner gloves and walk away from the clean area. Go to the rehabilitation area for medical monitoring, rehydration, and personal decontamination shower.

To don a Level B nonencapsulated chemical-protective clothing ensemble, follow the steps in **Skill Drill 7-3**:

1. Conduct a pre-entry briefing, medical monitoring, and equipment inspection. (**Step 1**)
2. Sit down, pull on the suit to waist level; pull on the chemical boots over the top of the chemical suit. Pull the suit boot covers over the tops of the boots. (**Step 2**)
3. Don the inner gloves. (**Step 3**)
4. With assistance, complete donning the suit by placing both arms in the suit and pulling the suit over the shoulders.
5. Instruct the assistant to close the chemical suit by closing the zipper and sealing the splash flap. (**Step 4**)
6. Don the SCBA frame and SCBA face piece, but do not connect the regulator to the face piece (**Step 5**)

Skill Drill 7-3

NFPA 472, 6.2.4.1

Donning a Level B Nonencapsulated Chemical-Protective Clothing Ensemble

1 Conduct a pre-entry briefing, medical monitoring, and equipment inspection.

2 While seated, pull on the suit to waist level; pull on the chemical boots over the top of the chemical suit. Pull the suit boot covers over the tops of the boots.

3 Don the inner gloves.

4 With assistance, complete donning the suit by placing both arms in suit and pulling suit over shoulders. Instruct the assistant to close the chemical suit by closing the zipper and sealing the splash flap.

5 Don the SCBA frame and SCBA face piece, but do not connect the regulator to the face piece.

6 With assistance, pull the hood over the head and SCBA face piece. Place the helmet on the head. Put on the outer gloves. Instruct the assistant to connect the regulator to the SCBA face piece and ensure you have air flow.

7. With assistance, pull the hood over the head and SCBA face piece.
8. Place the helmet on the head.
9. Pull the outer gloves over or under the sleeves, depending on the situation.
10. Instruct the assistant to connect the regulator to the SCBA face piece and ensure that the air flow is working correctly. (**Step 6**)
11. Review hand signals and indicate that you are okay.

Skill Drill 7-4

NFPA 472, 6.2.4.1

Doffing a Level B Nonencapsulated Chemical-Protective Clothing Ensemble

1 After completing decontamination, proceed to the clean area for suit doffing. Stand and doff the SCBA frame. Keep the face piece in place.

2 Instruct the assistant to open the chemical splash flap and suit zipper.

3 Remove your hands from the outer gloves and your arms from the sleeves of the suit. Cross your arms in front inside of the suit. Instruct the assistant to begin at the head and roll the suit down and away until the suit is below waist level.

4 Sit down and instruct the assistant to complete rolling down the suit to the ankles; step out of attached chemical boots and suit.

5 Stand and doff the SCBA face piece and helmet.

6 Carefully peel off the inner gloves and walk away from the clean area. Go to the rehabilitation area for medical monitoring, rehydration, and personal decontamination shower.

To doff a Level B nonencapsulated chemical-protective clothing ensemble, follow the steps in Skill Drill 7-4:

1. After completing decontamination, proceed to the clean area for suit doffing.
2. Stand and doff the SCBA frame. Keep the face piece in place while the SCBA frame is placed on the ground. (Step 1)
3. Instruct the assistant to open the chemical splash flap and suit zipper. (Step 2)
4. Remove your hands from the outer gloves and arms from the sleeves, and cross your arms in front inside the suit.
5. Instruct the assistant to begin at the head and roll the suit down and away until the suit is below waist level. (Step 3)
6. Sit down and instruct the assistant to complete rolling down the suit to the ankles. Step out of the outer boots and suit. (Step 4)
7. Stand and doff the SCBA face piece and helmet (Step 5).
8. Carefully peel off the inner gloves and go to the rehabilitation area for medical monitoring, rehydration, and personal decontamination shower. (Step 6)

Level C

A **Level C ensemble** is appropriate when the type of airborne contamination is known, its concentration is measured, and the criteria for using APRs are met. Typically, Level C ensembles are worn with an APR or PAPR. The complete ensemble consists of standard work clothing, chemical-protective clothing, chemical-resistant gloves, and a form of respiratory protection other than a SCBA or SAR system. Level C equipment is appropriate when significant skin and eye exposure is unlikely Figure 7-11. In many cases, Level C ensembles are worn in long-duration, low-hazard situations such as clean-up activities lasting hours or days; once an area is fully characterized and the hazards are found to be low enough to allow this level of protection; or after responders mitigate the problem to the extent that they can dress down to this lower level to complete the mission. Many law enforcement agencies have provided their officers with Level C ensembles to be carried in the trunk of patrol cars. Based on the mission of perimeter scene control, this may be a prudent level of protection.

Chapter 4 of this text provides a list of the recommended and optional components of a Level C protective ensemble, and reviews the conditions of use for APRs and PAPRs. The garment selected must meet the performance requirements for NFPA 1992, *Standard on Liquid Splash-Protective Ensembles and Clothing for Hazardous Materials Emergencies*. Respiratory protection may be provided by a half-face (with eye protection) or a full-face mask.

To don a Level C chemical-protective clothing ensemble, follow the steps in Skill Drill 7-5:

1. Conduct a pre-entry briefing, medical monitoring, and equipment inspection.
2. While seated, pull on the suit to waist level; pull on the chemical boots over the top of the chemical suit. Pull the suit boot covers over the tops of the boots. (Step 1)

Figure 7-11 Level C protective ensemble includes chemical-protective clothing and gloves as well as respiratory protection.

3. Don the inner gloves. (Step 2)
4. With assistance, complete donning the suit by placing both arms in the suit and pulling the suit over the shoulders.
5. Instruct the assistant to close the chemical suit by closing the zipper and sealing the splash flap. (Step 3)
6. Don APR/PAPR face piece.
7. With assistance, pull the hood over the head and the APR/PAPR face piece.
8. Place the helmet on the head.
9. Pull the outer gloves over or under the sleeves, depending on the situation.
10. Review hand signals and indicate that you are okay. (Step 4)

To doff a Level C chemical-protective clothing ensemble, follow the steps in Skill Drill 7-6:

1. After completing decontamination, proceed to the clean area for suit doffing.
2. As with level B, instruct the assistant to open the chemical splash flap and suit zipper.
3. Remove the hands from the outer gloves and your arms from the sleeves.
4. Instruct the assistant to begin at the head and roll the suit down and away until the suit is below waist level.
5. Instruct the assistant to complete rolling down the suit and take the suit and boots away.
6. Instruct the assistant to help remove the inner gloves.
7. Remove the APR/PAPR. Remove the helmet. (Step 1)

Skill Drill 7-5

NFPA 472, 6.2.4.1

Donning a Level C Chemical-Protective Clothing Ensemble

1 Conduct a pre-entry briefing, medical monitoring, and equipment inspection. While seated, pull on the suit to waist level; pull on the chemical boots over the top of the chemical suit. Pull the suit boot covers over the tops of the boots.

2 Don the inner gloves.

3 With assistance, complete donning the suit by placing both arms in the suit and pulling the suit over the shoulders. Instruct the assistant to close the chemical suit by closing the zipper and sealing the splash flap.

4 Don APR/PAPR. Pull the hood over the head and APR/PAPR. Place the helmet on the head. Pull on the outer gloves. Review hand signals and indicate that you are okay.

Skill Drill 7-6

NFPA 472, 6.2.4.1

Doffing a Level C Chemical-Protective Clothing Ensemble

1 After completing decontamination, proceed to the clean area. As with level B, the assistant opens the chemical splash flap and suit zipper. Remove the hands from the outer gloves and arms from the sleeves. Instruct the assistant to begin at the head and roll the suit down below waist level. Instruct the assistant to complete rolling down the suit and take the outer boots and suit away. The assistant helps remove inner gloves. Remove APR/PAPR. Remove the helmet.

2 Go to rehabilitation area for medical monitoring, rehydration, and personal decontamination shower.

8. Go to the rehabilitation area for medical monitoring, rehydration, and personal decontamination shower. (Step 2)

Level D

A **Level D ensemble** offers the lowest level of protection. It typically consists of coveralls, work shoes, hard hats, gloves, and standard work clothing Figure 7-12. This type of equipment should be used only when the atmosphere contains no known hazard, and when work functions preclude splashes, immersion, or the potential for unexpected inhalation of or contact with hazardous levels of chemicals. Level D protection should be used when the situation involves nuisance contamination (such as dust) only. It should not be worn on any site where respiratory or skin hazards exist. Chapter 4 provides a list of the recommended and optional components of Level D protection.

To don a Level D chemical-protective clothing ensemble, follow the steps in Skill Drill 7-7:

1. Conduct a pre-entry briefing and equipment inspection.
2. Don the Level D suit.
3. Don the boots.
4. Don safety glasses or chemical goggles.
5. Don a hard hat.
6. Don gloves, a face shield, and any other required equipment. (Step 1)

Table 7-1 describes the relationships among the NFPA hazardous materials protective clothing standards; the OSHA/EPA Level A, B, and C classifications; and the new NIOSH-certified respirator with CBRN protection standards. The table is intended to clarify the relationship between the NFPA guidelines and the OSHA standards and to summarize the expected performance of the ensembles.

Skill Drill 7-7

NFPA 472, 6.2.4.1

Donning a Level D Chemical-Protective Clothing Ensemble

1. Conduct pre-entry briefing and equipment inspection. Don the Level D suit. Don the boots. Don safety glasses or chemical goggles. Don a hard hat. Don gloves, a face shield, and any other required equipment.

Figure 7-12 A Level D protective ensemble is primarily a work uniform that includes coveralls and provides minimal protection.

Safety

There are many hazards associated with wearing PPE. These hazards are best addressed by understanding the NFPA performance requirements for chemical-protective ensembles and the safety considerations taken into account when wearing PPE.

Equipment Performance Requirements

Typical PPE performance requirements include tests for durability, barrier integrity after flex and abrasion challenges, cold-temperature flex, and flammability. Essentially, each part of the suit must pass a particular set of challenges prior to receiving certification based on the NFPA testing standards. Users of any garment that meets the performance requirements set forth by the NFPA can rest assured that the garment will withstand reasonable insults from most mechanical-type hazards encountered on the scene. Of course, achieving NFPA certification does not mean the suit is "bullet proof" and cannot fail; it just means that the equipment will hold up under "normal" conditions. It is up to the user to be aware of the hazards and avoid situations that may cause the garment to fail.

Responder Safety Tips

As exemplified by the TRACEMP acronym, many hazards can be encountered during the course of a hazardous materials incident. Given this possibility, multiple layers or multiple types of protection may have to be used in some situations. You should also understand the working environment and match the right garment to the anticipated hazards.

Table 7-1 Levels of Protection

NFPA Standard	OSHA/EPA Level	NIOSH-Certified Respirator	NFPA Chemical Barrier Protection Method(s)	Expected Dermal Protection from Suit(s): Chemical Vapor*	Chemical Liquid*	Particulate	Liquid-borne Biological (Aerosol)
1991	A	CBRN SCBA (open circuit)	Protection against permeation and penetration*	X	X	X	X
1992	B	Non-CBRN SCBA (or CBRN SCBA)	Protection against penetration*		X		
	C	Non-CBRN APR or PAPR	Protection against penetration		X		
1994, Class 1	(Note: The NFPA 1994, Class 1 ensemble, was removed in the 2006 edition of the standard because of its redundancy with NFPA 1991.)						
1994, Class 2	B	CBRN SCBA	Protection against permeation	X	X	X	X
1994, Class 3	C	CBRN APR or PAPR	Protection against permeation	X	X	X	X
1994, Class 4	B	CBRN SCBA	Protection against penetration	NA	NA	X	X
	C	CBRN APR or PAPR	Protection against penetration	NA	NA/NT	X	X

*Notes: Vapor protection for NFPA 1994 Class 2 and Class 3 is based on challenge concentrations established for NIOSH certification of CBRN open-circuit SCBA and APR/PAPR respiratory equipment. Class 2 and Class 3 do not require the use of totally encapsulating garments.

As described earlier, a variety of materials are used in both vapor- and splash-protective clothing. The most commonly used materials include butyl rubber, Tyvek, Saranex, polyvinyl chloride, and Vitron, either singly or in multiple layers consisting of several different materials. Special chemical-protective clothing is adequate for incidents involving some chemicals, yet useless for incidents involving other chemicals; no single fabric provides satisfactory protection from all chemicals.

All responders who may be called upon to wear any type of PPE should read and understand the manufacturer's specifications and procedures for the maintenance, testing, inspection, cleaning, and storage procedures for PPE provided by the AHJ. The list of NFPA and NIOSH documents in **Table 7-2** offers an overview of the testing and certification standards affecting the PPE currently on the market.

It is important for all responders to remember that some of the mission-specific competencies in this section are taken from competencies required of hazardous materials technicians. *That does not mean that operations level responders, with a mission-specific competency in PPE or any other mission-specific competency, are a replacement for a technician.*

Responder Safety

Working in PPE is a hazardous proposition on two different levels. First, simply by wearing PPE, the responder acknowledges that some degree of danger exists: If there were no hazard, there would be no need for the PPE! Second, wearing the PPE puts an inherent stress on the responder, separate and apart from the stress imposed by the operating environment. Much of the textbook is devoted to the "safety first" consideration. The next sections are devoted to raising your awareness of the issues that may arise from the very gear used to keep you safe.

Chapter 5 of this text outlined the various heat-related illnesses commonly experienced by responders. Those complications include heat exhaustion, heat cramps, and heat stroke, all of which are usually preceded by **dehydration**. Given that well-defined relationship, responders should be fully aware that their underlying level of hydration, prior to the response, may have an effect on their safety while they are wearing PPE. The next section, which covers heat exchange units, addresses that

Responder Tips

The authority having jurisdiction must properly outfit all responders expected to respond to a hazardous materials incident. The current OSHA HAZWOPER regulations [29 CFR 1910.120 (q)(3)(iii)] (and many local jurisdictional regulations) require the incident commander to ensure that the personal protective clothing worn at a hazardous materials emergency is appropriate for the hazards encountered.

Responder Tips

An **allied professional** may include a Certified Industrial Hygienist (CIH), Certified Safety Professional (CSP), Certified Health Physicist (CHP), or similar credentialed or competent individuals as determined by the AHJ.

Voices of Experience

A page came out that there was a hazardous materials incident at the local paper mill. Dispatch was vague with the details, but the local fire department commander had decided to call us in.

Upon arrival, the team leader assigned the team members our tasks. I was in charge of choosing the correct PPE for the entry team. The plant personnel informed us that "black liquor" was leaking from a fitting in a storage tank that was above 200°F. I was informed that the material was a highly caustic liquid and a by-product in the digestion of wood pulp. The plant captures this liquid, concentrates it, and then recycles it through the use of a recovery boiler.

I determined right away that we would need to perform a Level A entry because any skin exposure would not be acceptable. The "black liquor" would cause skin damage almost immediately. I wasn't able to find any specific information in the suit selection guides that were provided by the manufacturers, so I decided to call the toll-free number listed in the guide. The technician who answered the call was very knowledgeable and asked if I had one of the Level A suits with flash protection that the company sold. I informed him that we had several in our inventory. Upon his recommendation, we chose those suits to provide the entry team not only with chemical protection, but also protection from the temperature of the liquid should a rupture or catastrophic failure occur while the team members were stopping the leak.

"I wasn't able to find any specific information in the suit selection guides that were provided by the manufacturers, so I decided to call the toll-free number listed in the guide."

Everything went well. The entry team was able to stop the leak and get out without any problems. I was glad that I had called the manufacturer because I had been completely overlooking the thermal hazard and was focused only on the chemical properties of the liquid. If something had happened during the mitigation of the incident, I believe that the entry team would have been much better prepared for it because of the recommendation of the flash and chemical protection that the suits offered.

It is easy to get focused on one item and completely overlook the obvious. Calling the manufacturers of your PPE might not be something that you have to do very often, but they are a great resource and shouldn't be overlooked.

Jon Mink
Muskegon County Hazmat Team
Muskegon, Michigan

Table 7-2 PPE Testing and Certification Standards

Agency	Standard Title	Description
NFPA 1994	*Standard on Protective Ensembles for First Responders to CBRN Terrorism Incidents*	For chemicals, biological agents, and radioactive particulate hazards. Certifications under NFPA 1994 are issued only for complete ensembles. Individual elements such as garments or boots are not considered certified unless they are used as part of a certified ensemble. Thus purchasers of PPE certified under NFPA 1994 should plan to purchase complete ensembles (or certified replacement components for existing ensembles).
NFPA 1992	*Standard on Liquid Splash–Protective Ensembles and Clothing for Hazardous Materials Emergencies*	For liquid or liquid splash threats.
NFPA 1991	*Standard on Vapor-Protective Ensembles for Hazardous Materials Emergencies*	Includes the now-mandatory requirements for CBRN protection for terrorism incident operations for all vapor-protective ensembles. It also includes the qualifications for the former NFPA 1994 Class 1 protective ensemble.
NFPA 1951	*Standard on Protective Ensembles for Technical Rescue Incidents*	For search and rescue or search and recovery operations where exposure to flame and heat is unlikely or nonexistent.
NFPA 1999	*Standard on Protective Clothing for Emergency Medical Operations*	For protection from blood and body fluid pathogens for persons providing treatment to victims after decontamination.
NFPA 1981	*Standard on Open-Circuit Self-Contained Breathing Apparatus (SCBA) for Emergency Services*	For all responders who may use SCBA; must be certified by NIOSH.
NIOSH	*Chemical, Biological, Radiological and Nuclear (CBRN) Standard for Open-Circuit Self-Contained Breathing Apparatus*	To protect emergency responders against CBRN agents in terrorist attacks. Compliance with NFPA 1981.
NIOSH	*Standard for Chemical, Biological, Radiological, and Nuclear (CBRN) Full Facepiece Air-Purifying Respirator (APR)*	To protect emergency response workers against CBRN agents.
NIOSH	*Standard for Chemical, Biological, Radiological, and Nuclear (CBRN) Air-Purifying Escape Respirator and CBRN Self-Contained Escape Respirator*	To protect the general worker population against CBRN agents.

fact by revisiting dehydration and the various cooling technologies that may be used to reduce the effects of overheating inside a chemical-protective garment.

Responders should also be aware that their field of vision is compromised by the face piece of a SCBA or APR and even by the encapsulating suit. This factor may result in the responder slipping in a puddle of spilled chemicals or tripping on something. Moreover, the face piece often fogs up at some point, further limiting the responder's vision. This creates many problems, such as the inability to read labels; see other responders; see the screens on detection and monitoring devices; or quickly find an escape route in the event of an unforeseen problem in the hot zone. Wearing bulky PPE, such as an encapsulating suit, may inhibit the mobility of the wearer to the point that bending over becomes difficult or reaching for valves above head level is taxing. Furthermore, when gloves become contaminated with chemicals (especially solvents), they become slippery, making it difficult to effectively grip tools, handrails, or ladder rungs. All in all, the environment inside the PPE can be just as challenging as the conditions outside the suit!

To mitigate some of the potential safety considerations that arise when wearing PPE, responders can employ a variety of safety procedures and training. To begin, conducting a pre-entry medical evaluation is important to catch the medical indicators that may signal a responder should not wear PPE. Chapter 5 outlines the specific components of a pre-entry medical monitoring plan. Further guidance can also be found in NFPA 473, *Standard for Competencies for EMS Personnel Responding to Hazardous Materials/WMD Incidents,* in either the basic life support or advanced life support section. Keep in mind that the medical monitoring station may serve many purposes at the scene of a hazardous materials event. The primary role of the medical monitoring station is to evaluate the medical status of the entry team, the backup team, and those personnel assigned to decontamination duties. On the scene of larger incidents, a medical group or team may be required to obtain the basic physiological information from each responder and plan to provide care in the event a responder becomes a patient.

The use of the buddy system is another way that responders can mitigate some of the hazards that may be encountered at the scene of a hazardous materials/WMD incident. As mentioned earlier in this text, the OSHA HAZWOPER regulation requires the use of the buddy system. Along with buddy system comes the need to communicate—another potential safety issue on the scene. Prior to entry, all radio communications should be sorted out and tested. To back up that form of communication, all responders on the scene should have a method to communicate by universally accepted hand signals. These hand signals could be used to rapidly share messages about problems with an air supply, a suit problem, or any other problem that might occur in the hot zone. Communications are often problematic on emergency scenes, so take whatever steps you can to minimize problems before anyone enters a contaminated atmosphere.

Heat Exchange Units

Hazardous materials responders operating in protective clothing should be aware of the signs and symptoms of heat exhaustion, heat stress, heat stroke, dehydration, and illness caused by extreme cold. Chapter 5 provides detailed information on heat and cold disorders. The most common malady striking anyone wearing PPE is heat related. If the body is unable to disperse heat because an ensemble of PPE covers it, serious short- and long-term medical issues could occur.

Most heat-related illnesses are typically preceded by dehydration. For responders, it is important to stay hydrated so that they can function at their maximum capacity. As a frame of reference, athletes should consume approximately 500 mL (16 oz) of fluid (water) prior to an event and 200–300 mL of fluid at regular intervals during the event. Responders can be considered occupational athletes—so keep up on your fluids! OSHA Fact Sheet number 95-16, "Protecting Workers in Hot Environments," provides additional information about the dangers of heat-related illness in the workplace.

In an effort to combat heat stress while wearing PPE, many response agencies employ some form of cooling technology under the garment. These technologies include, but are not limited to, air, ice, and water-cooled vests, along with phase-change cooling technology. Many studies have been conducted on each form of cooling technology. Each of these approaches is designed to accomplish the same goal—to reduce the impact of heat stress on the human body. As mentioned earlier, the same suit that seals you up against the hazards also seals in the heat, defeating the body's natural cooling mechanisms.

Forced-air cooling systems operate by forcing prechilled air through a system of hoses worn close to the body. This is similar to the fluid-chilled system described below. As the cooler air passes by the skin, heat is drawn away—by convection—from the body and released into the atmosphere. Forced-air systems are designed to function as the first level of cooling the body would naturally employ. Typically, these systems are lightweight and provide long-term cooling benefits, but mobility is limited because the umbilical is attached to an external, fixed compressor.

Ice-cooled or gel-packed vests are commonly used due to their low cost, unlimited portability, and unlimited "recharging" by refreezing the packs **Figure 7-13**. These garments are vest-like in their design and intended to be worn around the torso. The principle underlying this approach is that the ice-chilled vest absorbs the heat generated by the body. On the downside, this technology is bulkier and heavier than the aforementioned systems, and it may cause discomfort to the wearer due to the nature of the ice-cold vest near the skin. Additionally, the cold temperature near the skin may actually fool the body into thinking it is cold instead of hot, thereby encouraging retention of even more heat.

Figure 7-13 Ice-cooled system.

Responder Safety Tips

Approximately 90 percent of all body heat is generated by the organs and muscles located in your torso.

Responder Safety Tips

Remember to take rehabilitation breaks throughout the hazardous materials incident. Wearing any type of PPE requires a great deal of physical energy and mental concentration. Responders should also acknowledge the psychological stress that wearing PPE may present. Claustrophobia is a common problem with wearing chemical-protective equipment, and especially encapsulated suits. This is one of the "P" (psychogenic) considerations in TRACEMP and can present a problem for responders.

Figure 7-14 A fluid-chilled or water-cooled system.

Figure 7-15 Phase-change cooling technology.

Fluid-chilled systems operate by pumping ice-chilled liquids (water is often used, so that these systems are referred to as "water cooled") from a reservoir, through a series of tubes held within a vest-like garment, and back to the reservoir Figure 7-14. Mobility may be limited with some varieties of this system, as the pump may be located away from the garment. Some systems incorporate a battery-operated unit worn on the hip, but the additional weight may increase the body's workload and generate more heat, thereby defeating the purpose of the cooling vest.

Phase-change cooling technology operates in a similar fashion to the ice- or gel-packed vests Figure 7-15. The main difference between the two approaches is that the temperature of the material in the phase-change packs is chilled to approximately 60°F, and the fabric of the vest is designed to wick perspiration away from the body. The packs typically "recharge" more quickly than those of an ice- or gel-packed vest. Even though the temperature of the phase-change pack is higher than the temperature of an ice- or gel-packed vest, it is sufficient to absorb the heat generated by the body.

Reporting and Documenting the Incident

As with any other type of incident, documenting the activities carried out during a hazardous materials/WMD incident is an important part of the response. Many responders may pass through the scene, and it could be quite difficult to sort everything out when it comes time to reconstruct the events for an accurate and legally defensible incident report. Good documentation after the incident is directly correlated with how well organized the response was.

Along with the formal written accounts of the event, some agencies require that personnel fill out exposure records that include information such as the name of the substances involved in the incident and the level of protection used. This information, coupled with a comprehensive medical surveillance program (see Chapter 4), provides a method to chronicle the exposure history of the responders over a period of time. Consult your AHJ for the exact details and procedures for reporting and documenting the incident.

Wrap-Up

Chief Concepts

- Using a risk-based approach is important when selecting personal protective equipment. All decisions should be well thought out and realistic, taking into account the positive and negative effects of the actions taken.
- Emergency responders should be familiar with the policies and procedures of the local jurisdiction so as to ensure a consistent approach is taken when selecting the proper personal protective equipment.
- Chemical-protective clothing is classified into two main categories: vapor-protective clothing and liquid splash–protective clothing.
- Unlike the OSHA HAZWOPER standard, NFPA 1994 covers the performance of the garment *and* factors in the performance of the respiratory protection.
- Levels A, B, and C are defined in the OSHA HAZWOPER standard, 29 CFR 1910.120, Appendix B.
- Typically, Level A protection is required when the operating environment exceeds IDLH values for skin absorption.
- According to the OSHA HAZWOPER regulation, Level B equipment is the minimum level of protection to be worn when operating in an unknown environment.
- Level C protection is appropriate when the type of airborne substance is known, its concentration is measured, and the criteria for using APRs are met.
- The most common malady striking anyone wearing PPE is heat related. In an effort to combat heat stress while wearing PPE, many response agencies employ some form of cooling technology under the garment.
- Manufacturers' guidelines for maintenance, testing, inspection, storage, and documentation procedures should be followed for all personal protective equipment provided by the AHJ.
- Along with the formal written accounts of the event, some agencies require personnel to fill out exposure records that include information such as the name of the substances involved in the incident and the level of protection used.

Hot Terms

Air-purifying respirator (APR) A device worn to filter particulates and contaminants from the air before it is inhaled. Selection of the filter cartridge for an APR is based on the expected contaminants.

Allied professional A person with unique skills, knowledge, and/or abilities who may be called upon to assist hazardous materials responders. Examples of allied professionals may include a Certified Industrial Hygienist (CIH), Certified Safety Professional (CSP), Certified Health Physicist (CHP), or similar credentialed or competent individuals as determined by the authority having jurisdiction.

Chemical-resistant materials Clothing (suit fabrics) specifically designed to inhibit or resist the passage of chemicals into and through the material by the process of penetration, permeation, or degradation.

Degradation The physical destruction or decomposition of a clothing material owing to chemical exposure, general use, or ambient conditions (such as storage in sunlight). Materials can also be tested for weight changes, loss of fabric tensile strength, and other properties to measure degradation.

Dehydration An excessive loss of body water. Signs and symptoms of dehydration may include increasing thirst, dry mouth, weakness or dizziness, and a darkening of the urine or a decrease in the frequency of urination.

Doffing The process of taking off an ensemble of PPE.

Donning The process of putting on an ensemble of PPE.

High-efficiency particulate air (HEPA) filter A filter that is used in conjunction with self-contained breathing apparatus or simple respirators and that catches particles down to 0.3-micron size—much smaller than a typical dust particle or anthrax spore. These filters are used to protect responders from alpha emitters by protecting the respiratory tract.

High temperature–protective equipment A type of personal protective equipment that shields the wearer during short-term exposures to high temperatures. Sometimes referred to as a proximity suit, this type of equipment allows the properly trained fire fighter to work in extreme fire conditions. It is not designed to protect against hazardous materials or weapons of mass destruction.

Level A ensemble Personal protective equipment that provides protection against vapors, gases, mists, and even dusts. The highest level of protection, it requires a totally encapsulating suit that includes self-contained breathing apparatus.

Level B ensemble Personal protective equipment that is used when the type and atmospheric concentration of substances requires a high level of respiratory protection but less skin protection. The kinds of gloves and boots worn depend on the identified chemical.

Level C ensemble Personal protective equipment that is used when the type of airborne substance is known, the concentration is measured, the criteria for using an air-purifying respirator are met, and skin and eye exposure is unlikely. A Level C ensemble consists of standard work clothing with the addition of chemical-protective clothing, chemically resistant gloves, and a form of respirator protection.

Wrap-Up

Level D ensemble Personal protective equipment that is used when the atmosphere contains no known hazard, and work functions preclude splashes, immersion, or the potential for unexpected inhalation of or contact with hazardous levels of chemicals. A Level D ensemble is primarily a work uniform that includes coveralls and affords minimal protection.

Liquid splash–protective clothing Clothing designed to protect the wearer from chemical splashes. It does not provide total body protection from gases or vapors and should not be used for incidents involving liquids that emit vapors known to affect or be absorbed through the skin. NFPA 1992 is the performance document pertaining to liquid-splash garments and ensembles.

National Institute for Occupational Safety and Health (NIOSH) The organization that sets the design, testing, and certification requirements for self-contained breathing apparatus in the United States.

Penetration The flow or movement of a hazardous chemical through closures such as zippers, seams, porous materials, pinholes, or other imperfections in a material. Liquids are most likely to penetrate a material, but solids (such as asbestos) can also penetrate protective clothing materials.

Permeation The process by which a hazardous chemical moves through a given material on the molecular level. Permeation differs from penetration in that permeation occurs through the material itself rather than through openings in the material.

Powered air-purifying respirator (PAPR) A type of air-purifying respirator that uses a battery-powered blower to pass outside air through a filter and then to the mask via a low-pressure hose.

Self-contained breathing apparatus (SCBA) A respirator with independent air supply used by fire fighters to enter toxic or otherwise dangerous atmospheres.

Supplied-air respirator (SAR) A respirator that obtains its air through a hose from a remote source such as a compressor or storage cylinder. A hose connects the user to the air source and provides air to the face piece. SARs are useful during extended operations such as decontamination, clean-up, and remedial work. Also referred to as positive-pressure air-line respirators (with escape units).

Vapor-protective clothing Fully encapsulating chemical protective clothing that offers full-body protection from highly contaminated environments and requires air-supplied respiratory protection devices such as self-contained breathing apparatus. NFPA 1991 sets the performance standards for these types of garments, which are commonly referred to as Level A ensembles.

Responder *in Action*

The chief of your fire company has asked you to give a brief presentation to the town council about the new Level A suits you are planning to purchase. You decide to use the example of an ammonia release at a local ice-making facility to underscore the reasons why your company needs this particular level of protection.

1. Which of the following NFPA standards would be the proper one to reference regarding your new Level A suits?

A. NFPA 1981, *Standard on Open-Circuit Self-Contained Breathing Apparatus for Emergency Services* (2007 edition)

B. NFPA 1951, *Standard on Protective Ensembles for Technical Rescue Incidents* (2007 edition)

C. NFPA 1999, *Standard on Protective Clothing for Emergency Medical Operations* (2008 edition)

D. NFPA 1991, *Standard on Vapor-Protective Ensembles for Hazardous Materials Emergencies* (2005 edition)

2. You also choose to mention that the OSHA HAZWOPER regulation requires the incident commander to ensure that appropriate personal protective equipment must be worn at a hazardous materials emergency. Which part of the OSHA HAZWOPER standard would be the proper piece to quote?

A. 29 CFR 1910.120(q)(3)(iii)

B. 29 CFR 1910.120(a)

C. 29 CFR 1910.134

D. 49 CFR 1910.22(f)

3. In addition to the garment, you also plan to purchase a forced-air cooling system. Which of the following gives the most accurate description of forced-air cooling technology?

A. Forced-air cooling systems operate by pumping ice-chilled liquids from a reservoir, through a series of tubes held within a vest-like garment, and back to the reservoir.

B. The principle of forced-air cooling systems is that an ice-chilled vest absorbs the heat generated by the body. This technology may cause discomfort to the wearer because the ice-cold vest is placed so close to the skin.

C. Forced-air cooling systems operate by forcing pre-chilled air through a system of hoses worn close to the body. As the cooler air passes by the skin, it is drawn away from the body and released into the atmosphere.

D. Forced-air cooling technology operates by chilling the hands and feet with ice-chilled liquids in an attempt to increase manual dexterity.

4. Which of the following is a true statement?

A. Forced-air cooling technology is bulky and heavy.

B. With forced-air cooling technology, the temperature of the material in the packs is approximately 60°F.

C. Forced-air cooling technology is lightweight and provides long-term benefits.

D. Forced-air cooling technology is recharged by re-freezing the packs.