International Association of Fire Chiefs

National Fire Protection Association

# Georgia Fire Academy

## HAZARDOUS MATERIALS
## Awareness and Operations

GEORGIA PUBLIC SAFETY TRAINING CENTER
KNOWLEDGE SKILL ABILITY

## Student Manual

Funded by The
Georgia Emergency Management Agency

CHAPTER

# 1

## NFPA 472 Standard

### Competencies for Awareness Level Personnel

**4.1 General.**

**4.1.1 Introduction.**

**4.1.1.1** Awareness level personnel shall be persons who, in the course of their normal duties, could encounter an emergency involving hazardous materials/weapons of mass destruction (WMD) and who are expected to recognize the presence of the hazardous materials/WMD, protect themselves, call for trained personnel, and secure the area. [p. 6–8]

**4.1.1.2** Awareness level personnel shall be trained to meet all competencies of this chapter. [p. 6–8]

**4.1.1.3** Awareness level personnel shall receive additional training to meet applicable governmental occupational health and safety regulations. [p. 6–8]

### Core Competencies for Operations Level Responders

**5.1 General.**

**5.1.1 Introduction.**

**5.1.1.1** The operations level responder shall be that person who responds to hazardous materials/weapons of mass destruction (WMD) incidents for the purpose of protecting nearby persons, the environment, or property from the effects of the release. [p. 8–10]

**5.1.1.2** The operations level responder shall be trained to meet all competencies at the awareness level (Chapter 4) and the competencies in this chapter. [p. 8–10]

**5.1.1.3** The operations level responder shall receive additional training to meet applicable governmental occupational health and safety regulations. [p. 8–10]

## Knowledge Objectives

After studying this chapter, you will be able to:

- Define a hazardous material.
- Define weapons of mass destruction (WMD).
- Describe the different levels of hazardous materials training: awareness, operations, technician, specialist, and incident commander.
- Understand the difference between the standards and federal regulations that govern hazardous material response activities.
- Explain the difference between hazardous materials incidents and other emergencies.
- Explain the need for a planned response to a hazardous materials incident.

## Skills Objectives

There are no skills objectives for this chapter.

## You Are the Responder

Your crew responds to a report of a suspicious odor at a small plastics manufacturing company. When you arrive, you notice a tractor-trailer delivery truck parked at the loading dock, with the motor still idling. You can see only one side of the trailer—it has a red diamond-shaped placard on it that reads "Flammable," with a number 3 on the bottom. You notice the odor as soon as you roll down the window. The facility security guard reports that several people can smell something like "paint thinner" in the air.

1. When you received the call from dispatch, which information led you to believe that this incident could involve hazardous materials?
2. Does the placard on the side of the truck provide any clues about the nature of the cargo inside?
3. Do you suspect terrorism or some other act committed with criminal intent?

## Introduction

Fire fighters, law enforcement personnel, and emergency medical services personnel may be called upon to respond to a variety of incidents involving hazardous materials or weapons of mass destruction (WMD). These incidents may include structural fires, emergency medical calls, automobile accidents, confined-space rescues, drug laboratories, incidents at industrial plants, and incidents involving terrorism. These and other emergency situations may involve hazardous substances that threaten lives, property, and/or the environment. When an emergency involves hazardous materials or WMD, the nature of the incident changes from that of a typical structure fire or medical response, and so must the mentality of the responder.

With proper training and situational awareness, responders can stay safe and make good decisions that positively change the outcome of any incident. From a broad perspective, the goal of this textbook is to help you learn how to recognize the presence of a hazardous material/WMD incident, take initial actions including establishing scene control zones, implement the Incident Command System, use basic reference sources such as the *Emergency Response Guidebook (ERG)*, perform appropriate decontamination when necessary, and ultimately understand where you fit into a full-scale hazardous materials/WMD response Figure 1-1 ▸.

In addition, you will be provided with information regarding mission-specific responsibilities in the areas of personal protective equipment, technical and mass decontamination, evidence preservation, product control, basic air monitoring, victim rescue, and incidents occuring at illicit laboratories, based on the needs of the Authority Having Jurisdiction (AHJ). The AHJ is the governing body that sets operational policy and procedures for the jurisdiction in which you operate. Ultimately, you should be able to operate safely at a wide

Figure 1-1 The ability to recognize a potential hazardous material/WMD incident is a critical first step to ensuring your safety.

### Responder Tips

The *Emergency Response Guidebook (ERG)* is a preliminary action guide containing information regarding approximately 4000 chemicals. The *ERG* should not be used to create a long-term action plan, however. Once the incident progresses beyond the first 15 minutes or so, the *ERG* is no longer an appropriate source of information. Responders at the scene should seek additional specifics about any material in question by consulting the appropriate emergency response agency or utilizing the emergency response number on a shipping document, if applicable, to gather more information.

variety of hazardous materials/WMD incidents. Regulations enforced by the U.S. federal agency Occupational Safety and Health Administration (OSHA) and the U.S. federal agency Environmental Protection Agency (EPA) as well as consensus-based standards such as the National Fire Protection Association (NFPA) 472 standard, *Standard for Competence of Responders to Hazardous Materials/Weapons of Mass Destruction Incidents*, are in place to help you achieve this goal. The intent of this text is not to make you an expert on hazardous materials/WMD or on the regulations and standards that govern your response, but to help you become a more informed responder.

## Hazardous Materials

A hazardous material, as defined by the U.S. Department of Transportation (DOT), is any substance or material that is capable of posing an unreasonable risk to human health, safety, or the environment when transported in commerce, used incorrectly, or not properly contained or stored. The term "hazardous material" also includes hazardous substances, wastes, marine pollutants, and elevated-temperature materials.

As the title implies, the definition of a hazardous material as found in the 2008 edition of NFPA 472, *Standard for Competence of Responders to Hazardous Materials/Weapons of Mass Destruction Incidents*, includes the criminal use of hazardous materials, such as weapons of mass destruction (WMD). This definition encompasses illicit laboratories, environmental crimes, or industrial sabotage. It is for this reason that the text will refer to hazardous materials and WMD simultaneously.

From an emergency responder's perspective, a hazardous material can be almost anything, depending on the situation. Milk, for example, is not routinely regarded as a hazardous substance—but 5000 gallons of milk leaking into a creek does, in fact, pose an unreasonable risk to the environment. A large chlorine gas release also fits the definition, as would any substance used as a terrorist weapon. Regarding the threat of terrorism, it would be unwise to believe that your jurisdiction is immune to deliberate criminal acts. Such an event could happen anywhere, at any time, with any type of substance.

Hazardous materials can be found anywhere Figure 1-2. From hospitals to petrochemical plants, pure chemicals and chemical mixtures are used to create millions of consumer products. According to the Chemical Abstracts Service (CAS), which produces the largest databases on chemical information including the CAS Registry, approximately 40 million organic and inorganic substances are registered for use in commerce in the United States, with several thousand new ones being introduced each year. The bulk of the new chemical substances are industrial chemicals, household cleaners, and lawn care products.

**Responder Safety Tips**

Responding personnel must be able to identify the chemicals involved in a release and place them in the proper context. In other words, ask yourself these questions: What is the chemical? What are the conditions under which it was released? What is it going to do next?

Figure 1-2 A hazardous material can be found anywhere.

Manufacturing processes sometimes generate hazardous wastes. A hazardous waste is what remains after a process or manufacturing activity has used a particular substance and the material is no longer pure. Hazardous waste can be just as dangerous as pure chemicals. It can also comprise mixtures of several chemicals, which may make it difficult to determine how the substance will react when it is released or if it comes in contact with other chemicals. The waste generated by the illegal production of methamphetamine, for example, may produce a dangerous mixture of chemical wastes.

## Levels of Training: Regulations and Standards

To understand where you fit in as a responder, you must first recognize some of the regulatory drivers that apply to hazardous materials response, beginning with the difference between a regulation and a standard. *Regulations* are issued and enforced by federal governmental bodies such as OSHA (part of the U.S. Department of Labor) and the EPA. Conversely, *standards* are issued by nongovernmental entities and are generally consensus based. A standard may be voluntary, meaning that an agency such as a fire department may not be required to adopt and follow the standard completely. For example, organizations such as the NFPA issue voluntary consensus-based standards that the public can comment on before committee members

**Responder Safety Tips**

An awareness and an understanding of your surroundings is your first defense against danger. Be aware of the hazards in your response area.

agree to adopt them. The technical committee responsible for periodically revising any NFPA standard is required to meet regularly; revise, update, and possibly change a standard; and review and take action on any public comments during the revision process. Once the standard is finalized, agencies may *choose* to adopt it.

**Responder Tips**

NFPA standards are voluntary and consensus based, which means that they can be adopted entirely or in part by an agency. This status is different than that of OSHA laws and regulations; compliance with OSHA mandates is not voluntary.

Each state in the United States has the right to adopt and/or supercede workplace health and safety regulations put forth by the federal agency OSHA. States that have adopted the OSHA regulations are called state-plan states. California, for example, is a state-plan state; its regulatory body is called Cal-OSHA. About half of the states in the United States are state-plan states. States that have not adopted the OSHA regulations are non-plan states. Non-plan states are considered to be EPA states because they follow Title 40 of the Code of Federal Regulations (CFR), *Protection of the Environment, Part 311, Worker Protection.* The CFR is a collection of permanent rules published by the federal government. It includes 50 titles that represent broad areas of interest that are governed by federal regulation.

**Responder Tips**

Responders should understand the relationship between the OSHA regulations and the NFPA standards when it comes to hazardous materials response. OSHA regulations are the law that governs hazardous materials responders; NFPA standards are guidelines that agencies choose to adopt. NFPA 472 clearly states: "First responders at the operational level also shall receive any additional training to meet applicable DOT, EPA, OSHA, and other state, local, or provincial occupational health and safety regulatory requirements."

NFPA standards governing hazardous materials/WMD response come from the Technical Committee on Hazardous Materials Response Personnel. This group includes more than 30 members from private industry, the fire service and law enforcement, professional organizations, and governmental agencies. Currently, two published standards are especially important to personnel who may be called upon to respond to hazardous materials/WMD incidents: NFPA 472, *Standard for Competence of Responders to Hazardous Materials/Weapons of Mass Destruction Incidents*, and NFPA 473, *Standard for Competencies for EMS Personnel Responding to Hazardous Materials/Weapons of Mass Destruction Incidents.* Extracts from each standard can be found in Appendix A and Appendix B. Generally speaking,

**Canadian Perspectives**

Those jurisdictions in Canada that have adopted a standard for training personnel in hazardous materials response have selected NFPA 472, *Standard for Competence of Responders to Hazardous Materials/Weapons of Mass Destruction Incidents.*

NFPA 472 outlines training competencies for all hazardous materials responders; NFPA 473 spells out the competencies required for emergency medical services (EMS) personnel rendering medical care at hazardous materials/WMD incidents.

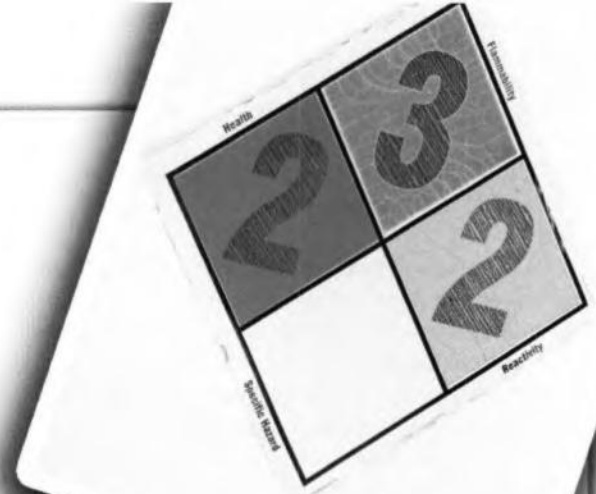
In the United States, the NFPA standards as well as EPA and OSHA regulations are important to those personnel called upon to respond to hazardous materials/WMD incidents. The OSHA document containing the hazardous materials response competencies is commonly referred to as HAZWOPER (HAZardous Waste OPerations and Emergency Response). The complete HAZWOPER regulation can be found in CFR, Title 29, standard 1910.120. See Appendix D of this text for the HAZWOPER regulation. The training levels found in HAZWOPER, much like the training levels found in the NFPA 472 standard, are identified as awareness, operations, technician, specialist (*specialist* is recognized only in the OSHA/HAZWOPER regulation), and incident commander. NFPA 472, since its first writing, has been updated every 5 years. This is a much more frequent revision cycle than that applied to the OSHA HAZWOPER regulation. This rapid revision cycle may be the source of some differences in the definitions of the levels of training represented here.

The following descriptions provide a broad overview, as found in NFPA 472 and the OSHA HAZWOPER regulation, of the different levels of hazardous materials/WMD responders and training competencies. When reading NFPA 472, it is important to understand that the standard is organized to first spell out the *tasks* that a responder (awareness, operations, technician, incident commander) may be called upon to perform on the scene. The subsequent *training competencies* follow. To stay focused on the intent of this textbook—which is to train responders to the awareness and operations level in accordance with the 2008 edition of NFPA 472—only the tasks that awareness level personnel and operations level responders may be expected to perform are discussed in detail. A general overview of the expectations for the other response levels—technician, specialist, and incident commander—is provided as well.

## Awareness Level

According to NFPA 472, awareness level personnel are those persons who, in the course of their normal duties, could encounter an emergency involving hazardous materials/WMD and who are expected to recognize the presence of the hazardous materials/WMD; protect themselves; call for trained personnel; and secure the area. In the 2008 revised edition of NFPA 472, a person with awareness level training is no longer considered to be a "responder." Instead, these individuals are now referred to as awareness level personnel. Persons receiving

# Voices *of* Experience




Over the last 30 years in which I have been involved in hazardous materials response, many changes have occurred. From the promulgation of the first regulations to the advent of the NFPA, it has been to the benefit of the first responder to have an understanding of how standards and regulations affect what we do.

One of the most interesting parts of the job is the exhilaration of a response, but *how* we respond is truly a result of what we have learned from the standards and regulations that we work with. We train to respond to hazardous materials incidents using the OSHA HAZWOPER regulation; NFPA 472, *Standard for Competence of Responders to Hazardous Materials/Weapons of Mass Destruction Incidents*; and NFPA 473, *Standard for Competencies for EMS Personnel Responding to Hazardous Materials/Weapons of Mass Destruction Incidents.* These regulations and standards are outgrowths of previous laws that established the basis for hazardous materials response, such as the Resource Conservation and Recovery Act of 1976 (RCRA), the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), and the Superfund Amendments and Reauthorization Act of 1986 (SARA).

Several years ago, while I was responding to an incident, I found that knowing the rules helped to assure we actually played by the rules. While working at an incident involving the spill of a nasty product, the state environmental and labor agencies began asking us questions about appropriate transportation, appropriate protection, cleanup, and disposal of the hazard. All of that information was listed on the material safety data sheet in the section that described spill, waste, and disposal considerations for the material. This information was available because of the RCRA, CERCLA, and SARA regulations. We had followed all of the rules and knew their importance to the responder. We must understand the *why* of *what* we do, and ensuring familiarity with and knowledge of the standards and regulations is a good way to protect ourselves throughout a hazardous materials incident.

*"One of the most interesting parts of the job is the exhilaration of a response, but how we respond is truly a result of what we have learned from the standards and regulations that we work with."*

Glen Rudner
Virginia Department of Emergency Management
Spotsylvania, Virginia

this level of training are not typically called to the scene to respond; rather, awareness level personnel, such as public works employees or fixed-site security personnel, function in support roles.

Tasks that awareness level personnel may be expected to perform on the scene include these duties:

- Analyzing the incident to detect the presence of hazardous materials/WMD
- Identify the name, United Nations/North American Hazardous Materials Code (UN/NA) identification number, type placard, or other distinctive marking applied for the hazardous materials/WMD involved
- Collect information from the current edition of the *ERG* about the hazard
- Initiate and implement protective actions consistent with the emergency response plan, the standard operating procedures, and the current edition of the *ERG*
- Initiate the notification process

OSHA's HAZWOPER view of the awareness level is slightly different, mostly because it relates to classifying awareness level personnel as "responders." According to OSHA (1910.120(q)(6)(i)), "first responders at the awareness level are individuals who are likely to witness or discover a hazardous substance release and who have been trained to initiate an emergency response sequence by notifying the proper authorities of the release. They would take no further action beyond notifying the authorities of the release." Based on the OSHA HAZWOPER regulation, first responders at the awareness level should have sufficient training or experience to objectively demonstrate competency in the following areas:

- An understanding of what hazardous substances are and the risks associated with them
- An understanding of the potential outcomes of an incident
- The ability to recognize the presence of hazardous substances
- The ability to identify the hazardous substances, if possible
- An understanding of the role of the first responder awareness individual in the emergency response plan
- The ability to determine the need for additional resources and to notify the communication center

## Operations Level

According to NFPA 472, operations level responders are those persons who are tasked to respond to hazardous materials/WMD incidents for the purpose of implementing or supporting actions to protect nearby persons, the environment, or property from the effects of the release. These persons may also have competencies that are specific to their response mission, expected tasks, and equipment and training as determined by the AHJ.

The 2008 edition of NFPA 472 significantly expands the scope of an operations level responder by separating the operations level suite of competencies into two distinct categories: core competencies and mission-specific competencies. *This is the most significant aspect of the revised standard, and the focus of this textbook.* The core competencies are based on those vital tasks that operations level personnel should perform on the scene of a hazardous materials/WMD incident. Some of those tasks are outlined here:

- Analyze the scene of a hazardous materials/WMD incident to determine the scope of the emergency
- Survey the scene to identify containers and materials involved
- Collect information from available reference sources
- Predict the likely behavior of a hazardous material
- Estimate the potential harm the substances might cause
- Plan a response to the release, including selection of the correct level of personal protective clothing
- Perform decontamination
- Preserve evidence
- Evaluate the status and effectiveness of the response

This abbreviated list should serve only as an illustration of the NFPA 472 core competencies; the specifics of each responsibility (along with the corresponding training competencies) are addressed throughout the remainder of the textbook. Keep in mind that the core training competencies are designed to provide the skills, knowledge, and abilities to safely accomplish the tasks listed above. Core competency training is required of

### NFPA 472 Awareness Level Tasks

**4.1.2.2** When already on the scene of a hazardous materials/WMD incident, the awareness level personnel shall be able to perform the following tasks:

(1) Analyze the incident to determine both the hazardous material/WMD present and the basic hazard and response information for each hazardous material/WMD agent by completing the following tasks:
  (a) Detect the presence of hazardous materials/WMD.
  (b) Survey a hazardous materials/WMD incident from a safe location to identify the name, UN/NA identification number, type of placard, or other distinctive marking applied for the hazardous materials/WMD involved.
  (c) Collect hazard information from the current edition of the DOT *Emergency Response Guidebook*.

(2) Implement actions consistent with the emergency response plan, the standard operating procedures, and the current edition of the DOT *Emergency Response Guidebook* by completing the following tasks:
  (a) Initiate protective actions.
  (b) Initiate the notification process.

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**Responder Tips**

The term "tasked to respond" may raise a question about your role as an operations level responder in an emergency response involving a hazardous material/WMD. To clarify this point, consider this scenario: If the local emergency response system you operate in—whether as a career professional or as a volunteer—is activated (e.g., 911 call), and your agency will respond to the scene to provide on-scene emergency services to the hazardous materials/WMD incident, you are viewed as a "responder." Personnel termed "responders" may include fire and rescue assets, law enforcement personnel, emergency medical services workers (basic or advanced life support providers), experts or other employees from private industry, and/or other allied professionals.

Figure 1-3 Operations level responders.

all operations level responders on the scene, no matter what their function. One of the goals of the NFPA 472 standard is to better match the expected tasks that may be required of the responder with the training that the responder should receive.

In addition to undertaking core competency training, an individual AHJ may find the need to do more training based on an identified or anticipated "mission-specific" need. To that end, those responders who are expected to perform additional missions, beyond the core competencies, shall be trained to carry out those mission-specific responsibilities. Remember—the revised version of NFPA 472 allows each agency to pick and choose the training program that makes the most sense *for its jurisdiction*. These mission-specific competencies are *non-mandatory* and should be viewed as optional. To that end, operations level responders may end up performing a limited suite of technician level skills, but do not have the broader knowledge and abilities of a hazardous materials technician.

NFPA 472 provides a mechanism to ensure that operations level responders, including those with mission-specific training, do not go beyond their level of training and equipment. This is done by using technician level personnel to provide direct guidance to the operations level responder operating on a hazardous materials/WMD incident. Operations level responders are expected to work under the direct control of a hazardous materials technician or allied professional, who has the ability to continuously assess and/or observe the actions of the operations level responder, *and* to provide immediate feedback. Guidance by a hazardous materials technician or an allied professional may be provided through direct visual observation or through assessments communicated from the operations level responder(s) to a technician. The concept of mission-specific competency training is also discussed in Chapter 5, Implementing the Planned Response.

This textbook follows the format of NFPA 472 in that after the core competencies have been covered, an individual chapter is devoted to each of the eight mission-specific competencies:

- Use of personal protective equipment
- Performing technical decontamination
- Performing mass decontamination
- Evidence preservation and sampling
- Performing product control
- Performing victim rescue and recovery operations
- Response to illicit laboratory incidents
- Performing air monitoring and sampling

According to the OSHA HAZWOPER regulation, first responders at the operations level are individuals who respond to releases or potential releases of hazardous materials incidents as part of their normal duties for the purpose of protecting nearby persons, property, or the environment from the effects of the release Figure 1-3. The OSHA HAZWOPER regulation mandates that the operations level responders must be trained to respond in a defensive fashion, without actually trying to stop the release directly, while avoiding contact with the released substance. Their function is to contain the release from a safe distance, keep it from spreading, and prevent or reduce the potential for human exposures. First responders at the operational level are expected to have received at least eight hours of training or to have had sufficient experience to objectively demonstrate competency in the following areas in addition to those listed for the awareness level:

- Knowledge of the basic hazard and risk assessment techniques
- Knowledge of how to select and use proper personal protective equipment provided
- An understanding of basic hazardous materials terms
- Knowledge of how to perform basic control, containment, and/or confinement operations within the capabilities of the resources and personal protective equipment available with their unit
- Knowledge of how to implement basic decontamination procedures
- An understanding of the relevant standard operating procedures and termination procedures

## Technician/Specialist Level

NFPA 472 defines individuals at the technician level as follows: The hazardous materials technician is a person who responds to hazardous materials/WMD incidents using a risk-based response process with the ability to:

## NFPA 472 Operations Level Tasks

**5.1.2.2** When responding to hazardous materials/WMD incidents, operations level responders shall be able to perform the following tasks:

(1) Analyze a hazardous materials/WMD incident to determine the scope of the problem and potential outcomes by completing the following tasks:
  (a) Survey a hazardous materials/WMD incident to identify the containers and materials involved, determine whether hazardous materials/WMD have been released, and evaluate the surrounding conditions.
  (b) Collect hazard and response information from MSDS; CHEMTREC/CANUTEC/SETIQ; local, state, and federal authorities; and shipper/manufacturer contacts.
  (c) Predict the likely behavior of a hazardous material/WMD and its container.
  (d) Estimate the potential harm at a hazardous materials/WMD incident.

(2) Plan an initial response to a hazardous materials/WMD incident within the capabilities and competencies of available personnel and personal protective equipment by completing the following tasks:
  (a) Describe the response objectives for the hazardous materials/WMD incident.
  (b) Describe the response options available for each objective.
  (c) Determine whether the personal protective equipment provided is appropriate for implementing each option.
  (d) Describe emergency decontamination procedures.
  (e) Develop a plan of action, including safety considerations.

(3) Implement the planned response for a hazardous materials/WMD incident to favorably change the outcomes consistent with the emergency response plan and/or standard operating procedures by completing the following tasks:
  (a) Establish and enforce scene control procedures, including control zones, emergency decontamination, and communications.
  (b) Where criminal or terrorist acts are suspected, establish means of evidence preservation.
  (c) Initiate an incident command system (ICS) for hazardous materials/WMD incidents.
  (d) Perform tasks assigned as identified in the incident action plan.
  (e) Demonstrate emergency decontamination.

(4) Evaluate the progress of the actions taken at a hazardous materials/WMD incident to ensure that the response objectives are being met safely, effectively, and efficiently by completing the following tasks:
  (a) Evaluate the status of the actions taken in accomplishing the response objectives.
  (b) Communicate the status of the planned response.

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- Analyze a problem involving hazardous materials/WMD.
- Select appropriate decontamination procedures.
- Control a release using specialized protective clothing and control equipment.

These persons may have additional competencies that are specific to their response mission, expected tasks, and equipment and training as determined by the AHJ. A number of very detailed training competencies for technician level training are outlined in Chapter 7 of NFPA 472. Technician level personnel are integral to the NFPA 472 standard because they are, in many cases, intended to "supervise" the activities of on-scene operations level responders.

According to the OSHA HAZWOPER regulation, individuals at the technician level respond to hazardous material releases or potential releases for the purpose of stopping the release Figure 1-4 ›. Conceptually, this is similar in intent to NFPA 472 in that a technician will likely assume a more aggressive role than a first responder at the operations level. Technicians typically function at a higher level in terms of their cognitive approach to the response. They should be proficient at implementing a comprehensive risk-based approach to solving the problem. They will approach the point of release to plug, patch, or otherwise mitigate the problem.

According to the OSHA HAZWOPER standard, hazardous materials technicians should have received at least 24 hours of training equal to the first responder operations level. In addition, technicians should have the competency, knowledge, and understanding necessary to fulfill the following duties:

- Implement the employer's emergency response plan
- Classify, identify, and verify known and unknown materials by using field survey instruments and equipment
- Function within an assigned role in the Incident Command System
- Select and use proper specialized chemical personal protective equipment
- Understand hazard and risk assessment techniques
- Perform advance control, containment, and/or confinement operations within the capabilities of the resources and personal protective equipment available with the unit
- Understand and implement decontamination procedures
- Understand termination procedures
- Understand basic chemical and toxicological terminology and behavior

The specialist level is identified only in the OSHA HAZWOPER standard. This level of responder receives more specialized training than a hazardous materials technician. Practically speaking, however, the two levels are not dramatically different. The focus of this textbook is on the specifics of the operations level responder, not on the technician/specialist level responder.

Figure 1-4 Hazardous materials technicians.

## Incident Commander

According to NFPA 472, the incident commander (IC) is the person who is responsible for all incident activities, including the development of strategies and tactics and the ordering and the release of resources. The incident commander must receive any additional training necessary to meet applicable governmental occupational health and safety regulations and specific needs of the jurisdiction.

The OSHA HAZWOPER standard requires specific IC Hazardous Materials level training for those assuming command of a hazardous materials incident requiring action beyond the operations level. Individuals trained as incident commanders should have at least operations level training as well as additional training specific to commanding a hazardous materials incident. Incident commanders, who will assume control of the incident scene beyond the first responder awareness level, must receive at least 24 hours of training equal to the first responder operations level and also have competency in the following areas:

- Know and implement the employer's incident command system
- Know how to implement the employer's emergency response plan
- Know and understand the hazards and risks associated with chemical protective clothing
- Know how to implement the local emergency response plan
- Know of the state emergency response plan and of the Federal Regional Response Team
- Know and understand the importance of decontamination procedures

For more complete information regarding the IC Hazardous Materials position, refer to Chapter 8 of NFPA 472.

In addition to the initial training requirements for all response levels listed earlier, OSHA regulations require annual refresher training of sufficient content and duration to ensure that responders maintain their competencies or that they demonstrate competency in those areas at least yearly. Consult your local agency for more specific information on refresher training, other hazardous materials laws, regulations, and regulatory agencies.

## Other Governmental Agencies

In addition to OSHA and the EPA, several other governmental agencies are concerned with various aspects of hazardous materials/WMD response. The DOT, for example, promulgates and publishes laws and regulations that govern the transportation of goods by highway, rail, pipeline, air, and, in some cases, marine transport.

As discussed earlier in this chapter, the EPA regulates and governs issues relating to hazardous materials in the environment. The EPA's version of OSHA's HAZWOPER can be found in CFR Title 40, *Protection of the Environment, Part 311, Worker Protection*. In addition to creating standardized training for hazardous materials response and hazardous waste site operations, the Superfund Amendments and Reauthorization Act of 1986 (SARA) created a method and standard practice for a local community to understand and be aware of the chemical hazards in the community. Under SARA Title III, the Emergency Planning and Community Right to Know Act (EPCRA) requires a business that handles certain types and amounts of chemicals to report storage type, quantity, and storage methods to the fire department and the local emergency planning committee. This activity may be quite complex and should be undertaken only by those personnel who fully understand the requirements and the process.

Local Emergency Planning Committees (LEPC) gather and disseminate information about hazardous materials to the public. These voluntary organizations are made up of members of industry, transportation, media, fire and police agencies, and the public at large; they are established to meet the requirements of EPCRA and SARA. Essentially, LEPCs ensure that local resources are adequate to respond to a chemical event in the community. Responders should be familiar with their local LEPC and know how their department works with this committee.

One piece of data collected by the LEPC is a material safety data sheet (MSDS). The MSDS is a detailed profile of a single chemical or mixture of chemicals provided by the manufacturer and/or supplier of a chemical Figure 1-5 ▸. The MSDS details specific information about a chemical's physical and chemical properties, toxicological data, and appropriate first aid information in case of an accidental human exposure. These chemical-specific data sheets are an important source of information for responders when dealing with hazardous materials/WMD incidents. Responders also utilize the services of national response centers; local, state, and federal authorities; and shipper/manufacturer contacts when dealing with an incident. Later chapters will discuss MSDS and other reference sources in more detail.

Each state has a State Emergency Response Commission (SERC). The SERC acts as the liaison between local and state levels of authority. Its membership includes representatives from agencies such as the fire service, police services, and elected officials. The SERC is charged with the collection and dissemination of information relating to hazardous materials emergencies.

**MATERIAL SAFETY DATA SHEET**
**ANHYDROUS AMMONIA**

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| NATIONAL AMMONIA | NORTHEASTERN AMMONIA |
| HAMLER INDUSTRIES | BOWER AMMONIA & CHEMICAL |

735 Davisville Road, Third Floor, Southampton, PA 18966; 215-322-1238
**CORPORATE EMERGENCY TELEPHONE NUMBER: 800-643-6226 CHEMTREC: 800-424-9300**

**DESCRIPTION**

**CHEMICAL NAME**: Ammonia, Anhydrous **CAS REGISTRY NO**: 7664-41-7
**SYNONYMS**: Ammonia **CHEMICAL FAMILY**: Inorganic Nitrogen Compound
**FORMULA**: $NH_3$ **MOL. WT**: 17.03 ($NH_3$) **COMPOSITION**: 99+% Ammonia

**STATEMENT OF HEALTH HAZARD**

**HAZARD DESCRIPTION**:
Ammonia is an irritant and corrosive to the skin, eyes, respiratory tract and mucous membranes. Exposure to liquid or rapidly expanding gases may cause severe chemical burns and frostbite to the eyes, lungs and skin. Skin and respiratory related diseases could be aggravated by exposure.
Not recognized by OSHA as a carcinogen.
Not listed in the National Toxicology Program.
Not listed as a carcinogen by the International Agency for Research on Cancer.

**EXPOSURE LIMITS FOR AMMONIA**: Vapor

| | | | |
|---|---|---|---|
| OSHA | 50 ppm, | 35 mg / $m^3$ PEL | 8 hour TWA |
| NIOSH | 35 ppm, | 27 mg / $m^3$ STEL 15 minutes | |
| | 25 ppm, | 18 mg / $m^3$ REL | 10 hour TWA |
| | 300 ppm, | IDLH | |
| ACGIH | 25 ppm, | 18 mg / $m^3$ TLV | 8 hour TWA |
| | 35 ppm, | 27 mg / $m^3$ STEL 15 minutes | |

**TOXICITY**: LD 50 (Oral - Rat) 350 mg / kg

**PHYSICAL DATA**

**BOILING POINT**: -28°F at 1 Atm.
**PH**: N/A
**SPECIFIC GRAVITY OF GAS (air = 1)**: 0.596 at 32°F
**SPECIFIC GRAVITY OF LIQUID (water = 1)**: 0.682 at 28°F (Compared to water at 39°F).
**PERCENT VOLATILE**: 100% at 212°F
**APPEARANCE AND ODOR**: Colorless liquid or gas with pungent odor.
**CRITICAL TEMPERATURE**: 271.4°F
**GAS SPECIFIC VOLUME**: 20.78 $Ft^3$/Lb at 32°F and 1 Atm.
**VAPOR DENSITY**: 0.0481 Lb/$Ft^3$ at 32°F
**LIQUID DENSITY**: 38.00 Lb/$Ft^3$ at 70°F
**APPROXIMATE FREEZING POINT**: -108°F
**WEIGHT (per gallon)**: 5.15 pounds at 60°F
**VAPOR PRESSURE**: 114 psig at 70°F
**SOLUBILITY IN WATER (per 100 pounds of water)**: 86.9 pounds at 32°F, 51 pounds at 68°F
**SURFACE TENSION**: 23.4 Dynes / cm at 52°F
**CRITICAL PRESSURE**: 111.5 atm

**Figure 1-5** An example of an MSDS for anhydrous ammonia.

## The Difference Between a Hazardous Materials/WMD Incident and Other Types of Emergencies

Fire fighters should not approach a hazardous materials/WMD incident with the same mindset used in structural firefighting. Similarly, law enforcement officers should be mindful of the hazardous materials implications of some actions, such as responding to clandestine drug laboratory incidents. Most of the time, and certainly when lives are not at stake, response to a hazardous materials/WMD emergency takes more time than it would take to fight a structure fire or serve a search warrant to a high-risk suspect. Such response will *not* require responders to rush headlong into the problem. By contrast, if a rescue is required, or if the situation is imminently dangerous in some other way and requires quick action, events may move quickly. For the most part, however, a hazardous materials/WMD emergency requires time, forethought, and planning to ensure that the incident is handled safely and effectively.

Responders must understand that actions taken at hazardous materials/WMD incidents are largely dictated by the chemicals or hazards involved; environmental influences such as wind, rain, and temperature; and the way the chemicals behave during the release. Additionally, those personnel operating at the scene of a hazardous materials/WMD incident must be conscious of the potential or actual law enforcement aspect of the incident. Especially where terrorist or other criminal acts are suspected, responders should be mindful of evidenciary issues associated with the incident. Regardless of the type of attack or dissemination method, once it is determined that an intentional criminal attack has occurred, it becomes imperative that evidence be preserved and collected properly. Being mindful of evidentiary issues at a hazardous materials/WMD event may facilitate later efforts to identify, capture, and prosecute the person responsible for the act. For this series of events to unfold successfully, every responder on scene must be cognizant of the impact his or her presence will have on potential evidence. Although evidence preservation should never impede fire suppression or life-saving operations, every responder should be diligent in remembering that his or her actions and observations may play a vital role in the successful prosecution of a criminal suspect.

Response objectives, the choice of personal protective equipment, and the type of decontamination are complicated decisions that largely depend on the physical and chemical properties of the substance. When approaching hazardous materials events, make a conscious effort to change your perspective. Slow down, think about the problem and available resources, and take well-considered actions to solve it.

### Preplanning

It is a mistake to assume that a response to a hazardous materials/WMD incident begins when the alarm sounds. In reality, the response begins with your initial training, continuing education, and preplanning activities at target hazards and other potential problem areas throughout the jurisdiction or response district Figure 1-6. Target hazards include any occupancy type or facility that presents a high potential for loss of life or serious impact to the community resulting from fire, explosion, or chemical release.

**Responder Tips**

The goal of the emergency responder is to favorably change the outcome of the hazardous materials incident. This is accomplished by sound planning and by establishing safe and reasonable response objectives based on the level of training. Don't do it if you're not trained to do it!

**Figure 1-6** Conduct preincident planning activities at target hazards throughout the jurisdiction.

Preplanning activities enable agencies to develop logical and appropriate response procedures for anticipated incidents. Planning should focus on the real threats that exist in your community or adjacent communities you could be assisting. Preplanning at major target hazards should include discussions and information sharing with the LEPC.

Once the threats have been identified, fire departments, police agencies, public health offices, and other governmental agencies should determine how they will respond and work together in case of a large-scale emergency. In many cases, the move toward interoperability before an incident will make the actual emergency response work run smoothly.

# Wrap-Up

## Chief Concepts

- Governmental entities such as OSHA and the EPA issue and enforce regulations concerning hazardous materials emergencies.
- The consensus-based NFPA standards relating to hazardous materials/WMD incidents are available for those agencies that choose to adopt them.
- A hazardous material is any substance or material that is capable of posing an unreasonable risk to human health, safety, or the environment when transported in commerce, used incorrectly, or not properly contained or stored.
- The actions taken at hazardous materials/WMD incidents are largely dictated by the chemicals involved and the way they behave during the release.
- Two published NFPA standards are important to responders who may be called upon to respond to hazardous materials/WMD incidents: NFPA 472, *Standard for Competence of Responders to Hazardous Materials/Weapons of Mass Destruction Incidents*, and NFPA 473, *Standard for Competencies for EMS Personnel Responding to Hazardous Materials/Weapons of Mass Destruction Incidents*.
- The OSHA HAZWOPER regulation is found in the CFR, Title 29, Standard 1910.120.
- The EPA's version of OSHA's HAZWOPER can be found in CFR Title 40, *Protection of the Environment, Part 311: Worker Protection*.
- The goals associated with the competencies of awareness level personnel are to recognize a potential hazardous materials emergency, to isolate the area, and to call for assistance. Awareness level personnel take protective actions only.
- The 2008 edition of NFPA 472 expands the scope of an operations level responder's duties by making a distinction between core competencies and mission-specific competencies.
- For those who choose to adopt the NFPA 472 standard, the core competencies are required for all operations level responders; each agency can then pick and choose to require any or all of the mission-specific responsibilities. The core competencies of operations level responders are defensive actions.
- The mission-specific responsibilities of operations level responders include personal protective equipment, technical and mass decontamination, evidence preservation, product control, basic air monitoring, victim rescue, and incidents occurring at illicit laboratories.
- Hazardous materials technicians will approach the point of release so as to plug, patch, or otherwise mitigate a hazardous materials emergency.
- The hazardous materials incident commander is responsible for all incident activities.

## Hot Terms

Authority Having Jurisdiction (AHJ) The governing body that sets operational policy and procedures for the jurisdiction you operate in.

Awareness level personnel Persons who, in the course of their normal duties, could encounter an emergency involving hazardous materials/weapons of mass destruction (WMD) and who are expected to recognize the presence of hazardous materials/WMD, protect themselves, call for trained personnel, and secure the area.

Chemical Abstracts Service (CAS) A division of the American Chemical Society. This resource provides hazardous materials responders with access to an enormous collection of chemical substance information—the CAS Registry.

Code of Federal Regulations (CFR) A collection of permanant rules published in the *Federal Register* by the

executive departments and agencies of the U.S. federal government. Its 50 titles represent broad areas of interest that are governed by federal regulation. Each volume of the CFR is updated annually and issued on a quarterly basis.

Department of Transportation (DOT) The U.S. government agency that publicizes and enforces rules and regulations that relate to the transportation of many hazardous materials.

Emergency Planning and Community Right to Know Act (EPCRA) Legislation that requires a business that handles chemicals to report on those chemicals' type, quantity, and storage methods to the fire department and the local emergency planning committee.

*Emergency Response Guidebook (ERG)* A preliminary action guide for first responders operating at a hazardous materials incident in coordination with the U.S. Department of Transportation's (DOT) labels and placards marking system. The DOT and the Secretariat of Communications and Transportation of Mexico (SCT), along with Transport Canada, jointly developed the *Emergency Response Guidebook*.

Environmental Protection Agency (EPA) Established in 1970, the U.S. federal agency that ensures safe manufacturing, use, transportation, and disposal of hazardous substances.

Hazardous material Any substance or material that is capable of posing an unreasonable risk to human health, safety, or the environment when transported in commerce, used incorrectly, or not properly contained or stored.

Hazardous waste A substance that remains after a process or manufacturing plant has used some of the material and the substance is no longer pure.

HAZWOPER (HAZardous Waste OPerations and Emergency Response) The federal OSHA regulation that governs hazardous materials waste site and response training. Specifics can be found in book 29, standard number 1910.120. Subsection (q) is specific to emergency response.

Incident commander (IC) A level of training intended for those assuming command of a hazardous materials incident beyond the operations level. Individuals trained as incident commanders should have at least operations level training and additional training specific to commanding a hazardous materials incident.

Local Emergency Planning Committee (LEPC) Committee made up of members of industry, transportation, the public at large, media, and fire and police agencies that gathers and disseminates information on hazardous materials stored in the community and ensures that there are adequate local resources to respond to a chemical event in the community.

Material safety data sheet (MSDS) A form, provided by manufacturers and compounders (blenders) of chemicals, containing information about chemical composition, physical and chemical properties, health and safety hazards, emergency response, and waste disposal of a material.

National Fire Protection Association (NFPA) The association that develops and maintains nationally recognized minimum consensus standards on many areas of fire safety and specific standards on hazardous materials.

Occupational Safety and Health Administration (OSHA) The U.S. federal agency that regulates worker safety and, in some cases, responder safety. OSHA is a part of the U.S. Department of Labor.

Operations level responders Personnel who respond to hazardous materials/WMD incidents for the purpose of implementing or supporting actions to protect nearby

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persons, the environment, or property from the effects of the release.

Regulations Mandates issued and enforced by governmental bodies such as the U.S. Occupational Safety and Health Administration and the U.S. Environmental Protection Agency.

Specialist level (OSHA/HAZWOPER only) A hazardous materials specialist who responds with, and provides support to, hazardous materials technicians. This individual's duties parallel those of the hazardous materials technician; however, the technician's duties require a more directed or specific knowledge of the various substances he or she may be called upon to contain. The hazardous materials specialist also acts as the incident-site liaison with federal, state, local, and other government authorities in regard to site activities.

Standards Guidelines issued by nongovernmental entities that are generally consensus based.

State Emergency Response Commission (SERC) The liaison between local and state levels that collects and disseminates information relating to hazardous materials emergencies. SERC includes representatives from agencies such as the fire service, police services, and elected officials.

Superfund Amendments and Reauthorization Act of 1986 (SARA) One of the first U.S. laws to affect how fire departments respond in a hazardous material emergency.

Target hazards Any occupancy type or facility that presents a high potential for loss of life or serious impact to the community resulting from fire, explosion, or chemical release.

Technician level A person who responds to hazardous materials/WMD incidents using a risk-based response process by which he or she analyzes a problem involving hazardous materials/WMD, selects applicable decontamination procedures, and controls a release using specialized protective clothing and control equipment.

Weapons of mass destruction (WMD) Weapons whose use is intended to cause mass casualties, damage, and chaos. The NFPA includes the use of WMD in its definition of *hazardous materials*.

# Responder *in Action*

Your volunteer fire company has just accepted five new members. You are tasked with providing them with hazardous materials training, so you spend several weeks preparing to instruct the class. The new members are assigned a preclass assignment to read through NFPA 472, *Standard for Competence of Responders to Hazardous Materials/Weapons of Mass Destruction Incidents*, and to answer the following questions pertinent to the regulatory part of their training. Your instructional plan is to use this quiz to reinforce the main points of your introductory lecture.

1. Which standard describes the hazardous materials training competencies for operations level responders?
   - **A.** NFPA 473, *Standard for Competencies for EMS Personnel Responding to Hazardous Materials/Weapons of Mass Destruction Incidents*
   - **B.** NFPA 472, *Standard for Competence of Responders to Hazardous Materials/Weapons of Mass Destruction Incidents*
   - **C.** Code of Federal Regulations 1910.150 (q)
   - **D.** CFR Title 40, Protection of the Environment, Part 311: *Worker Protection*
2. NFPA 472 expands the scope of an operations level responder by separating the operations level competencies into two distinct categories. What are these two categories?
   - **A.** Technical and specialized competencies
   - **B.** Basic and advanced competencies
   - **C.** OSHA and NFPA competencies
   - **D.** Core and mission-specific competencies
3. According to the OSHA HAZWOPER regulation, which of the following competencies is *not* required of an operations level responder?
   - **A.** Knowledge of the basic hazard and risk assessment techniques
   - **B.** Knowledge of how to select and use proper personal protective equipment provided to the first responder
   - **C.** Knowledge of how to perform basic control, containment, and/or confinement operations within the capabilities of the resources and personal protective equipment available with the responder's unit
   - **D.** Knowledge of the classification, identification, and verification of known and unknown materials by using field survey instruments and equipment
4. What is the name of the federal document containing the hazardous materials response competencies? This regulation, issued in the late 1980s, standardized training for hazardous materials response and for hazardous waste site operations.
   - **A.** NFPA 471; paragraph 4, subsection (q)
   - **B.** NFPA 473; section 5.2.2.1
   - **C.** NFPA 472; CFR, book number 29, part 1910.120
   - **D.** HAZWOPER; CFR, book number 29, part 1910.120 subpart (q)

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# CHAPTER 2

## NFPA 472 Standard

### Competencies for Awareness Level Personnel

**4.4 Competencies—Implementing the Planned Response.**

**4.4.1 Initiating Protective Actions.** Given examples of hazardous materials/WMD incidents, the emergency response plan, the standard operating procedures, and the current edition of the DOT *Emergency Response Guidebook*, awareness level personnel shall be able to identify the actions to be taken to protect themselves and others and to control access to the scene and shall meet the following requirements:

(1) Identify the location of both the emergency response plan and/or standard operating procedures. [p. 22–39]

(2) Identify the role of the awareness level personnel during hazardous materials/WMD incidents. [p. 22–39]

(3) Identify the following basic precautions to be taken to protect themselves and others in hazardous materials/WMD incidents:

(a) Identify the precautions necessary when providing emergency medical care to victims of hazardous materials/WMD incidents. [p. 32–39]

(b) Identify typical ignition sources found at the scene of hazardous materials/WMD incidents. [p. 24]

(c) Identify the ways hazardous materials/WMD are harmful to people, the environment, and property. [p. 22–39]

(d) Identify the general routes of entry for human exposure to hazardous materials/WMD. [p. 35–38]

(4) Given examples of hazardous materials/WMD and the identity of each hazardous material/WMD (name, UN/NA identification number, or type placard), identify the following response information:

(a) Emergency action (fire, spill, or leak and first aid)

(b) Personal protective equipment necessary

(c) Initial isolation and protective action distances

(5) Given the name of a hazardous material, identify the recommended personal protective equipment from the following list:

(a) Street clothing and work uniforms

(b) Structural fire-fighting protective clothing

(c) Positive pressure self-contained breathing apparatus

(d) Chemical-protective clothing and equipment

(6) Identify the definitions for each of the following protective actions:

(a) Isolation of the hazard area and denial of entry

(b) Evacuation

(c) Sheltering in-place

(7) Identify the size and shape of recommended initial isolation and protective action zones.

(8) Describe the difference between small and large spills as found in the Table of Initial Isolation and Protective Action Distances in the DOT *Emergency Response Guidebook*.

(9) Identify the circumstances under which the following distances are used at a hazardous materials /WMD incidents:

(a) Table of Initial Isolation and Protective Action Distances

(b) Isolation distances in the numbered guides

(10) Describe the difference between the isolation distances on the orange-bordered guidebook pages and the protective action distances on the green-bordered ERG (*Emergency Response Guidebook*) pages.

(11) Identify the techniques used to isolate the hazard area and deny entry to unauthorized persons at hazardous materials/WMD incidents.

(12) Identify at least four specific actions necessary when an incident is suspected to involve criminal or terrorist activity.

### Core Competencies for Operations Level Responders

**5.2.2 Collecting Hazard and Response Information.** Given scenarios involving known hazardous materials/WMD, the operations level responder shall collect hazard and response information using MSDS, CHEMTREC/CANUTEC/SETIQ, governmental authorities, and shippers and manufacturers and shall meet the following requirements:

(1) Match the definitions associated with the UN/DOT hazard classes and divisions of hazardous materials/WMD, including refrigerated liquefied gases and cryogenic liquids, with the class or division.

(2) Identify two ways to obtain an MSDS in an emergency.

(3) Using an MSDS for a specified material, identify the following hazard and response information:

(a) Physical and chemical characteristics

(b) Physical hazards of the material

(c) Health hazards of the material

(d) Signs and symptoms of exposure

(e) Routes of entry

(f) Permissible exposure limits

(g) Responsible party contact

(h) Precautions for safe handling (including hygiene practices, protective measures, and procedures for cleanup of spills and leaks)

(i) Applicable control measures, including personal protective equipment

(j) Emergency and first-aid procedures

(4) Identify the following:

(a) Type of assistance provided by CHEMTREC/CANUTEC/SETIQ and governmental authorities

(b) Procedure for contacting CHEMTREC/CANUTEC/SETIQ and governmental authorities

(c) Information to be furnished to CHEMTREC/CANUTEC/SETIQ and governmental authorities

(5) Identify two methods of contacting the manufacturer or shipper to obtain hazard and response information.

(6) Identify the type of assistance provided by governmental authorities with respect to criminal or terrorist activities involving the release or potential release of hazardous materials/WMD.

(7) Identify the procedure for contacting local, state, and federal authorities as specified in the emergency response plan and/or standard operating procedures.

(8) Describe the properties and characteristics of the following:

(a) Alpha radiation [p. 30–32]

(b) Beta radiation [p. 30–32]

(c) Gamma radiation [p. 30–32]

(d) Neutron radiation [p. 30–32]

**5.2.3 Predicting the Likely Behavior of a Material and Its Container.** Given scenarios involving hazardous materials/WMD incidents, each with a single hazardous material/WMD, the operations level responder shall predict the likely behavior of the material/agent and its container and shall meet the following requirements:

(1) Interpret the hazard and response information obtained from the current edition of the *Emergency Response Guidebook*, MSDS, CHEMTREC/CANUTEC/SETIQ, governmental authorities, and shipper/manufacturer contacts, as follows:

(a) Match the following chemical and physical properties with their significance and impact on the behavior of the container and its contents:

i. Boiling point [p. 26]

ii. Chemical reactivity [p. 23]

iii. Corrosivity (pH) [p. 28–29]

iv. Flammable (explosive) range [lower explosive limit (LEL) and upper explosive limit (UEL)] [p. 25]

v. Flash point [p. 24–25]

vi. Ignition (autoignition) temperature [p. 25]

vii. Particle size [p. 30–32]

viii. Persistence [p. 34]

ix. Physical state (solid, liquid, gas) [p. 22–23]

x. Radiation (ionizing and non-ionizing) [p. 31–32]

xi. Specific gravity [p. 27–28]

xii. Toxic products of combustion [p. 29–30]

xiii. Vapor density [p. 27]

xiv. Vapor pressure [p. 25–26]

xv. Water solubility [p. 28]

(b) Identify the differences between the following terms:

i. *Contamination* and *secondary contamination* [p. 32]

ii. *Exposure* and *contamination* [p. 32]

iii. *Exposure* and *hazard* [p. 32]

iv. *Infectious* and *contagious* [p. 37]

v. *Acute effects* and *chronic effects* [p. 38–39]

vi. *Acute exposures* and *chronic exposures* [p. 38–39]

(2) Identify three types of stress that can cause a container system to release its contents. [p. 22–23]

(3) Identify five ways in which containers can breach. [p. 22–32]

(4) Identify four ways in which containers can release their contents. [p. 22–32]

(5) Identify at least four dispersion patterns that can be created upon release of a hazardous material. [p. 22–23]

(6) Identify the time frames for estimating the duration that hazardous materials/WMD will present an exposure risk. [p. 38–39]

(7) Identify the health and physical hazards that could cause harm. [p. 32–38]

(8) Identify the health hazards associated with the following terms:

(a) Alpha, beta, gamma, and neutron radiation [p. 30–32]

(b) Asphyxiant [p. 37]

(c) Carcinogen [p. 37]

(d) Convulsant [p. 35]

(e) Corrosive [p. 28–29]

(f) Highly toxic [p. 39]

(g) Irritant [p. 35]

(h) Sensitizer/allergen [p. 38–39]

(i) Target organ effects [p. 38–39]

(j) Toxic [p. 38–39]

(9) Given the following, identify the corresponding UN/DOT hazard class and division:

(a) Blood agents

(b) Biological agents and biological toxins

(c) Choking agents

(d) Irritants (riot control agents)

(e) Nerve agents

(f) Radiological materials

(g) Vesicants (blister agents)

## Knowledge Objectives

After studying this chapter, you will be able to:

- Describe the following properties:
  - Boiling point
  - Chemical reactivity
  - Corrosivity (pH)
  - Flammable (explosive) range [lower explosive limit (LEL) and upper explosive limit (UEL)]
  - Flash point
  - Ignition (autoignition) temperature
  - Particle size
  - Persistence
  - Physical state (solid, liquid, gas)
  - Radiation (ionizing and non-ionizing)
  - Specific gravity
  - Toxic products of combustion
  - Vapor density
  - Vapor pressure
  - Water solubility
  - Physical change and chemical change
- Describe radiation (non-ionizing and ionizing) as well as the difference between alpha and beta particles, gamma rays, and neutrons.
- Describe the differences between the following pairs of terms:
  - Contamination and secondary contamination
  - Exposure and contamination
  - Exposure and hazard
  - Infectious and contagious
  - Acute and chronic effects
  - Acute and chronic exposures
- Describe the following types of weapons of mass destruction:
  - Nerve agents
  - Blister agents
  - Choking agents
  - Irritants
- Describe the routes of exposure to hazardous materials for humans

## Skills Objectives

There are no skills objectives for this chapter.

## You Are the Responder

Just after midnight you receive a call for an explosion and a fire at a local landscaping company. Upon arrival at the site, you find a working fire in a 20′ × 20′ storage shed located behind the main building. The wooden shed is fully involved, so you begin an indirect attack on the fire from the outside of the shed. As the fire is being knocked down, you receive an order over the radio to shut down the attack and move away from the building. About the same time, you experience an itchy feeling on the back of your neck. Other crew members are also complaining of itching and burning sensations around their wrists and necks. Some lower-floor residents of an adjacent multistory apartment complex are complaining of eye irritation and asking about a strange odor in the air.

1. Which types of chemicals might be found in this kind of occupancy?
2. Where could you obtain accurate technical information on the products stored in this building?
3. Which actions should be taken to address the complaints of burning and itching skin among fire fighters as well as the complaints of the residents of the apartment complex?

## Introduction

To understand hazardous materials incidents, it is important to understand the chemical and physical properties of the substances involved. Chemical and physical properties are the characteristics of a substance that are measurable, such as vapor density, flammability, corrosivity, and water reactivity. However, you do not have to be a chemist to safely respond to hazardous materials incidents. In most cases, being an astute observer, referring to your emergency response plan and/or standard operating procedure, and correctly interpreting the visual clues presented to you will provide enough information to take basic actions at the incident.

This chapter will guide you in learning the basic hazardous materials concepts and key terms that will help you understand the information contained in reference sources such as the material safety data sheets (MSDS). To make good decisions about your initial emergency actions, you will need to understand the nature of the hazards and the problem you are facing.

## Physical and Chemical Changes

An important first step in understanding the hazards associated with any chemical involves identifying the state of matter, or physical state. The state of matter defines the substance as a solid, liquid, or gas Figure 2-1 ›.

If you know the state of matter and other physical properties of the chemical, you can begin to predict what the substance will do if it escapes from its containment vessel. For example, it would be vital to know if a released gas is heavier or lighter than air, and how that particular physical property relates to the environmental factors at the time of the incident, along with the other characteristics of the emergency scene. Imagine a release of a heavy gas such as propane in the setting of a trench rescue or other below-grade emergency: The physical properties of propane could be a complicating factor to performing a safe rescue in such a scenario.

Another critical part of comprehending the nature of the release comes from identifying the reason(s) why the contain-

Figure 2-1 The state of matter identifies the hazard as a solid, liquid, or gas. **A.** Solid. **B.** Liquid. **C.** Gas.

ment vessel failed. In many cases, responders focus on the fact that a substance *is* being released rather than understanding *why* the product is escaping its container. It's one thing to notice that a container is leaking or generating a cloud from a puncture, crack, split, or tear. It's equally important, however, to figure out what type of stress caused the vessel to breach or release its contents in the first place. Is the product release caused by a thermal influence—heat from inside or outside the container that may be the root cause of a catastrophic container failure? Maybe an errant forklift driver struck a drum, or a valve failure occurred. In these examples, physical damage allows the release of the container contents. In other cases, a chemical reaction inside a container may cause the entire container to breach.

Responders must also determine and/or estimate the time duration of the event. Incidents may last anywhere from seconds and minutes to several days, and in extreme cases, even months. Tactics and strategies may vary greatly depending on the projected duration of the event. At any hazardous materials incident, it's important to link together all the bits of information to make an informed decision about how to handle the problem.

Chemicals can undergo a physical change when they are subjected to environmental influences such as heat, cold, and pressure. For example, when water is frozen, it undergoes a physical change from a liquid to a solid. The actual chemical make-up ($H_2O$) of the water is still the same, but the state in which it exists is different. Here's another example of a physical change: Think of a Mr. Potato Head toy—taking off its arms and legs and changing them all around. Mr. Potato Head would still be the same toy—it would just look a bit different. A chemical change, by contrast, might involve a transformation in which Mr. Potato Head changes from plastic to wood.

Like water, propane gas is subject to physical change based on environmental influences such as heat and cold. If a propane cylinder is exposed to heat, the liquid propane inside changes phase, becoming gaseous propane—which, in turn, increases the pressure inside the vessel. If this uncontrolled expansion takes place faster than the relief valve can vent, a BLEVE could occur. A BLEVE (boiling liquid/expanding vapor explosion) occurs when pressurized liquefied materials (propane or butane, for example) inside a closed vessel are exposed to a source of high heat. In this case, the chemical make-up of propane has not changed; rather, the propane has physically changed state from liquid to gas.

The expansion ratio is a description of the volume increase that occurs when a liquid material changes to a gas. For example, propane has an expansion ratio of 270 to 1. This means that for every 1 volume of liquid propane, 270 times that amount of propane exists as vapor (the gas phase of a substance). If released into the atmosphere, 1 gallon of liquid propane would vaporize to 270 gallons of propane vapor.

Chemical reactivity (also known as chemical change) describes the ability of a substance to undergo a transformation at the molecular level, usually with a release of some form of energy. Physical change is essentially a change in state. By contrast, a chemical change results in an alteration of the chemical nature of the material. Steel rusting and wood burning are examples of chemical change.

To relate the concepts of physical and chemical change to a hazardous materials incident, think back to the initial case study. Assume for a moment that the owner of the landscape company wadded up some rags soaked with linseed oil and left them in the corner of the shed. The rags spontaneously ignited and started a fire that ultimately caused the failure of a small propane cylinder (the explosion that occurred prior to your arrival!). The fire also melted the fusible plug on a chlorine cylinder (at approximately 160°F [71°C]), causing a release of chlorine gas; chlorine gas is 2.5 times heavier than air.

Looking closely at each event in this sequence, you can see the impact of physical and chemical changes. Linseed oil is an organic material that generates heat as it decomposes (chemical change). That heat, in the presence of oxygen in the surrounding air, ignited the rags, which in turn ignited other combustibles. The surrounding heat caused the propane inside the tank to expand (physical change) until it overwhelmed the ability of the relief valve to handle the build-up of pressure. The cylinder ultimately exploded. The escaping chlorine gas mixed with the moisture in the air and formed an acidic mist (a chemical change). A slight breeze carried the smoke and mist toward the apartment complex. The fire fighters began to feel itchy and burning sensations where the acidic mist contacted their moist skin. Because chlorine vapors are heavier than air, most of the residents complaining about eye irritation are located on the bottom floor of the complex.

### Responder Safety Tips

**It is important to understand that chemical change is different from physical change. The reactive nature of any substance can be influenced in many ways, such as by mixing it with another substance (adding an acid to a base) or by applying heat.**

### Responder Safety Tips

**The classic example of a BLEVE is a fire occurring below or adjacent to a propane tank. Once the liquid inside the vessel begins to boil, large volumes of vapor are generated within the vessel. Ultimately, the vessel fails catastrophically if it is unable to relieve the pressure through the safety valve. The ensuing explosion throws fragments of the vessel in all directions. When the pressurized liquefied material is flammable, a tremendous fireball is generated. Additionally, an overpressure blast wave is created as a result of the rapidly expanding vapor released by the vessel failure. If fire is impinging on a vessel that contains pressurized liquefied materials, responders should carefully evaluate the risks of attempting to fight the fire. BLEVEs have claimed the lives of many fire fighters throughout the years—and this history should serve as a reminder of the dangers of these types of emergency situations.**

## Critical Characteristics of Flammable Liquids

When looking at the fire potential of a flammable liquid, several important aspects must be considered. Among them are flash point, ignition temperature, and flammable range. More important than memorizing the definitions for these terms, however, responders must understand the relationships between these and other physical characteristics of a flammable liquid. Keep in mind that when it comes to combustion (burning), all materials must be in a gaseous or vapor state: Solids do not burn, and liquids do not burn—they give off a gas or vapor that is ultimately ignited. Think of a log burning in a fireplace. If you look closely, the fire is not directly on the log, but rather appears slightly above the surface. The reason for this phenomenon is that the wood has to be heated to the point where it produces enough "wood gas" to support combustion. The log, then, does not burn—the gas produced by heating the log is what starts and sustains the process of combustion.

Conceptually, liquid fuels such as gasoline, diesel fuel, and other hydrocarbon-based dissolving solutions (solvents) behave the same way as the log. One way or another, vapor production must occur before there can be fire. This vapor production must be factored in when estimating the probability of fire during a release.

### Flash Point

Flash point is an expression of the minimum temperature at which a liquid or solid gives off sufficient vapors such that, when an ignition source (e.g., a flame, electrical equipment, lightning, or even static electricity) is present, the vapors will result in a flash fire. The flash fire involves only the vapor phase of the liquid (like the example of the log) and will go out once the vapor fuel is consumed.

To illustrate how such an event occurs, consider the flash point of gasoline at –45°F (–43°C). When the temperature of gasoline reaches –45°F (–43°C) as a result of heat from an external source or from the surrounding environment, it gives off sufficient flammable vapors to support combustion. In most all circumstances, when gasoline is spilled or otherwise released, the temperature of the external environment is well above the flash point of gasoline, creating the potential for ignition. Diesel fuel, by comparison, has a much higher flash point than gasoline—in the range of approximately 120°F (49°C) to 140°F (60°C), depending on the fuel grade. In either case, once the temperature of the liquid surpasses its flash point, the fuel will give off sufficient flammable vapors to support combustion Figure 2-2 ▸.

Additionally, liquids with low flash points—such as gasoline, ethyl alcohol, and acetone—typically have higher vapor pressures and higher ignition temperatures. Vapor pressure and ignition temperature are explained in more detail later in this chapter. Consider the case of gasoline, whose flash point is –45°F (–43°C). At a vapor pressure in excess of 275 mm Hg (compared to the vapor pressure of ethyl alcohol of 40 mm Hg at approximately 68°F [20°C]), gasoline has an ignition temperature of approximately 475°F (246°C). By contrast, flammable/combustible liquids with high flash points typically have lower ignition temperatures and lower vapor pressures. A particular grade of diesel—#2 grade diesel, for example—may have a flash point of 125°F (52°C) and a corresponding ignition temperature of approximately 500°F (260°C); this is clearly a much narrower range than that described in the gasoline example. The vapor pressure of #2 grade diesel fuel Table 2-1 ▴ is very low—much lower than the vapor pressure of water. Table 2-1 gives several other examples of flash points of flammable/combustible liquids, illustrating the relationships between flash point, ignition temperature, and vapor pressure.

**Table 2-1 Flash Point, Vapor Pressure, and Ignition Temperature**

| | Flash Point | Vapor Pressure | Ignition Temperature |
|---|---|---|---|
| **Water** | N/A | 25 mm Hg at 68°F (20°C) | N/A |
| **Gasoline** | –45°F (–43°C) | 275–400 mm Hg at 70°F (21°C) | 475°F (246°C) |
| **Acetone** | –4°F (–20°C) | 400 mm Hg at 104°F (40°C) | –465°F (-276°C) |
| **#2 Grade Diesel** | 125°F (52°C) | < 2 mm Hg at 68°F (20°C) | 500°F (260°C) |

A direct relationship also exists between temperature and vapor production. Simply put, when the temperature increases, the vapor production of any flammable liquid increases, leading to a higher concentration of vapors produced. Therefore, even liquids with low flash points can be expected to produce a significant amount of flammable vapors at all but the lowest ambient temperatures.

Flash point is merely one aspect to consider when flammable/combustible liquids are released from a container. The fire point is another definition that should be appreciated. Fire point is the temperature at which sustained combustion of the

Figure 2-2 Responders should always be mindful of ignition sources at flammable/combustible liquid incidents.

vapor will occur. It is usually only slightly higher than the flash point for most materials.

## Ignition Temperature

Ignition (autoignition) temperature is another important temperature landmark for flammable/combustible liquids. From a technical perspective, you can think of ignition temperature as the minimum temperature at which a fuel, when heated, will ignite in air and continue to burn.

From a responder's perspective, it is important to realize that when a liquid fuel is heated beyond its ignition temperature, from any type of heat, it will ignite without an external ignition source. Think of a pan full of cooking oil on the stove. For illustrative purposes, assume that the ignition temperature of the oil is 300°F (148°C). What would happen if the burner was set on high and left unattended, so that the oil was heated past 300°F (148°C)? Once the temperature of the oil exceeds its ignition temperature, it will ignite; there is no need for an external ignition source. In fact, this scenario is a common cause of stove fires.

## Flammable Range

Flammable range is another important term to understand. Defined broadly, flammable range is an expression of a fuel/air mixture, defined by upper and lower limits, that reflects an amount of flammable vapor mixed with a given volume of air. Gasoline will serve as our example. The flammable range for gasoline vapors is 1.4 percent to 7.6 percent. The two percentages, called the lower explosive limit (LEL) (1.4 percent) and the upper explosive limit (UEL) (7.6 percent), define the boundaries of a fuel/air mixture necessary for gasoline to burn properly. If a given gasoline/air mixture falls between the LEL and the UEL, and that mixture comes in contact with an ignition source, a flash fire will occur.

The concept of automobile carburetion capitalizes on the notion of flammable range—the carburetor is the place where gasoline and air are mixed. When the mixture of gasoline vapors and air occurs in the right proportions, the car runs smoothly. When there is too much fuel and not enough air, the mixture is considered to be too "rich." When there is too much air and not enough fuel, the carburetion is called too "lean." In either of these two cases, optimal combustion is not achieved and the motor does not run correctly.

Understanding flammable range, as it relates to hazardous materials response, is based on the same line of thinking. If gasoline is released from a rolled-over cargo tank, the vapors from the spilled liquid will mix with the surrounding air. If the mixture of vapors and air falls between the UEL and the LEL, and those vapors reach an ignition source, a flash fire will occur. Ultimately, the entire volume of gasoline will likely burn. As with carburetion, if too much or too little fuel is present, the mixture will not adequately support combustion.

Generally speaking, the wider the flammable range, the more dangerous the material Table 2-2 ▸. This relationship reflects the fact that the wider the flammable range, the more opportunity there is for an explosive mixture to find an ignition source.

**Table 2-2 Flammable Ranges of Common Gases**

| | |
|---|---|
| **Hydrogen** | 4.0%–75% |
| **Natural gas** | 5.0%–15% |
| **Propane** | 2.5%–9.0% |

## Vapor Pressure

For our purposes, the definition of vapor pressure will pertain to liquids held inside any type of closed container Figure 2-3 ▾. When liquids are held in a closed 55-gallon drum or a 4-liter glass bottle, for example, some amount of pressure (in the headspace above the liquid) will develop inside. All liquids, even water, will develop a certain amount of pressure in the airspace between the top of the liquid and the container.

The key point to understanding vapor pressure is this: *The vapors released from the surface of any liquid must be contained if they are to exert pressure.* Essentially, the liquid inside the container will vaporize until the molecules given off by the liquid reach equilibrium with the liquid itself. Equilibrium is a balancing act between the liquid and the vapors—some molecules turn to vapor, while others leave the vapor phase and return to the liquid phase.

Carbonated beverages illustrate this concept. Inside the basic cola drink is the super-secret formula for the soda and a certain amount of carbon dioxide ($CO_2$) molecules: $CO_2$ makes the bubbles in the soda. When the soda sits in an unopened can or plastic bottle on the shelf, the balancing act of $CO_2$ is happening: $CO_2$ from the liquid becomes gaseous $CO_2$ above the liquid; at the same time, some of the $CO_2$ dissolves back into the liquid. The pressure inside the bottle can be verified by feeling the rigidity of the container—until you open it. Once the lid is removed, the $CO_2$ is no longer in a closed vessel, and it escapes into the atmosphere. With the pressure released, the sides of the bottle can be squeezed easily. Ultimately, the soda goes flat because all of the $CO_2$ has escaped.

With the soda example in mind, consider the technical definition of vapor pressure: The vapor pressure of a liquid is the pressure exerted by its vapor until the liquid and the vapor are in equilibrium. Again, this process occurs inside a closed container, and temperature has a direct influence on the vapor

Figure 2-3 Vapor pressure.

**Responder Tips**

Two specific points of temperature 68°F (20°C) and pressure (14.7 psi) are commonly referred to as normal temperature and pressure (NTP). These values represent standard conditions under which chemical and physical properties can be tested and documented. Another term, standard temperature and pressure (STP), as defined by the International Union of Pure and Applied Chemistry (IUPAC), describes an ideal testing environment for a variety of chemical and physical processes: 14.7 psi at 32°F (0°C).

Figure 2-4 The concept of boiling point versus atmospheric pressure.

pressure. For example, if heat impinges on a drum of acetone, the pressure above the liquid will increase and perhaps cause the drum to fail. If the temperature is dramatically reduced, the vapor pressure will drop. This is true for any liquid held inside a closed container.

What happens if the container is opened or spilled onto the ground to form a puddle? The liquid still has a vapor pressure but it is no longer confined to a container. *In this case, we can conclude that liquids with high vapor pressures will evaporate much more quickly than do liquids with low vapor pressures.* Vapor pressure directly correlates to the speed with which a material will evaporate once it is released from its container.

For example, motor oil has a low vapor pressure. When it is released, it will stay on the ground a long time. Chemicals such as isopropyl alcohol and di-ethyl ether exhibit the opposite behavior: When either of these materials is released and collects on the ground, it will evaporate rapidly. If ambient air temperature or pavement temperatures are elevated, their evaporation rates will increase even further. Wind speed, shade, humidity, and the surface area of the spill also influence how fast the chemical will evaporate.

When consulting reference sources, be aware that the vapor pressure may be expressed in pounds per square inch (psi), atmospheres (atm), torr, or millimeters of mercury (mm Hg); most references give the vapor pressures of substances at a temperature of 68°F (20°C). Each expression of pressure is a valid point of reference in emergency response. The term "millimeters of mercury" (mm Hg) is commonly found in reference books; it is defined as the pressure exerted at the base of a column of fluid that is exactly 1 millimeter in height. The "torr" unit is named after the Italian physicist Evangelista Torricelli, who discovered the principle of the mercury barometer in 1644. In his honor, the torr was equated to 1 mm Hg. Certain conversion factors allow calculations from one reference point to another, but some of these factors are very complex. For the purposes of simplicity and emergency response, the important point is to have some frame of reference to understand the concept of vapor pressure and to recognize how that concept will impact the release of chemicals into the environment.

To understand the relationship between the various units of pressure, use the following comparison:

14.7 psi = 1 atmosphere (atm) = 760 torr = 760 mm Hg

Another method of comparison is to take the values from the reference books and compare those values to the behavior of substances you may be familiar with. The following example compares (using mm Hg) three common substances: water, motor oil, and iso-propyl alcohol. The vapor pressure of water at room temperature is approximately 25 mm Hg. Standard 40-weight motor oil has a vapor pressure of less than 0.1 mm Hg at 68°F (20°C)—it is practically vaporless at room temperature. Isopropyl alcohol, by contrast, has a high vapor pressure of 30 mm Hg at room temperature. Again, temperature has a direct correlation to vapor pressure, but all things being equal, these three substances give you a good starting point for making comparisons.

## Boiling Point

Boiling point is the temperature at which a liquid will continually give off vapors in sustained amounts and, if held at that temperature long enough, will turn completely into a gas. The boiling point of water, for example, is 212°F (100°C). At this temperature, water molecules have enough kinetic energy (energy in motion) to overcome the downward force of the surrounding atmospheric pressure (at sea level, a pressure of 14.7 psi is exerted on every surface of every object, including the surface of the water) Figure 2-4. At temperatures less than 212°F (100°C), there is insufficient heat to create enough kinetic energy to allow the water molecules to escape.

An illustration of boiling point, which demonstrates how heated liquids inside closed containers might create a deadly situation, can be found by looking at a completely benign and common example—popcorn. Fundamentally, popcorn pops when the trapped water inside the kernel of corn is heated beyond its boiling point. When the popcorn kernels are heated, the small amount of water inside each kernel eventually exceeds its boiling point and expands to 1700 times its original water volume. The kernel then "pops." A kernel of corn has no relief valve, so a rapid build-up of pressure will cause it to breach. Unpopped kernels are those with insufficient water inside the kernel to permit this expansion.

**Responder Safety Tips**

Flammable liquids with low boiling points are dangerous because they have the potential to produce large volumes of flammable vapor at relatively low temperatures.

### Responder Safety Tips

The molecular weight of a flammable liquid dictates the behavior of the substance once it is released. A molecule of motor oil, for example, is much larger than a molecule of isopropyl alcohol. Some general conclusions about the relationships among vapor pressure, boiling point, flash point, ignition temperature, and heat output can be linked together based on the molecular size of a chemical compound. Specifically, as the molecular weight of a substance increases:

- ⇓ Vapor pressure decreases.
- ⇑ Boiling point increases.
- ⇑ Flash point increases.
- ⇓ Ignition temperature decreases.
- ⇑ Heat output increases.

## Vapor Density

In addition to identifying the flammability of a particular vapor or gas, responders must determine whether the vapor or gas is heavier or lighter than air. In essence, you must know the vapor density of the substance in question. Vapor density is the weight of an airborne concentration of a vapor or gas as compared to an equal volume of dry air Figure 2-5.

Basically, vapor density is a question of comparison—what will the gas or vapor do when it is released in the air? Will it collect in low spots in the topography or somewhere inside a building, or will it float upward into the ventilation system or upward into the air? These are important response considerations for hazardous materials incidents and may influence the severity of the incident.

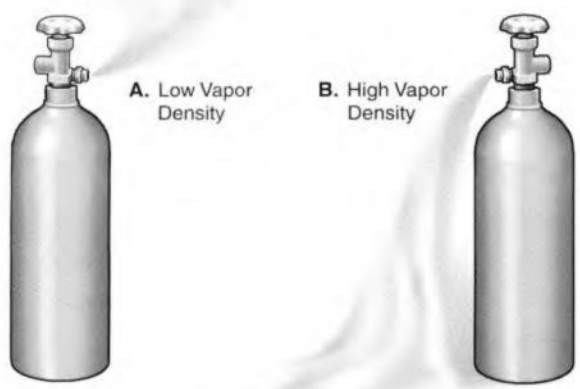



Figure 2-5 Vapor density. **A.** Vapor density <1.0 over the cylinder with the gas leak rising upward. **B.** Vapor density >1.0 over the cylinder with the heavier-than-air leak.

You can find a chemical's vapor density by consulting a good reference source such as an MSDS. The vapor density will be expressed in numerical fashion, such as 1.2, 0.59, or 4.0. The vapor density of propane, for example, is 1.51. Air has a set vapor density value of 1.0. Gases such as propane or chlorine are heavier than air and, therefore, have a vapor density value greater than 1.0. Substances such as acetylene, natural gas, and hydrogen are lighter than air and will have a vapor density value of less than 1.0.

In the absence of reliable reference sources in the field, there is a mnemonic you can use to remember a number of lighter-than-air gases: 4H MEDIC ANNA. This mnemonic translates as follows:

**H:** Hydrogen
**H:** Helium
**H:** Hydrogen cyanide
**H:** Hydrogen fluoride
**M:** Methane
**E:** Ethylene
**D:** Diborane
**I:** Illuminating gas (methane/ethane mixture)
**C:** Carbon monoxide
**A:** Ammonia
**N:** Neon
**N:** Nitrogen
**A:** Acetylene

If you encounter a leaking propane cylinder, for example, just refer back to 4H MEDIC ANNA. Propane is not on that list, so by default, you can assume that propane is heavier than air. You won't find chlorine or butane on the list, either: Both are heavier than air. Again, if the substance is not on this list, it is most likely heavier than air.

## Specific Gravity

Specific gravity is to liquids what vapor density is to gases and vapors—namely, a comparison value. In this case, the comparison is between the weight of a liquid chemical and the weight of water. Water is assigned a value of 1.0 as its specific gravity. Any material with a specific gravity value less than 1.0 will float on water. Any material with a specific gravity value greater than 1.0 will sink and remain below the surface of water. A comprehensive reference source will provide the specific gravity of the chemical in question.

Most flammable liquids will float on water Figure 2-6. Gasoline, diesel fuel, motor oil, and benzene are all examples of liquids that float on water. Carbon disulfide, by comparison, has a specific gravity of approximately 2.6. Consequently, if

### Responder Safety Tips

It is important to carefully consider the application of water in all cases involving spilled or released chemicals. Do not approach any problem with the "It's just water" mindset. The results could be something worse than the initial problem.

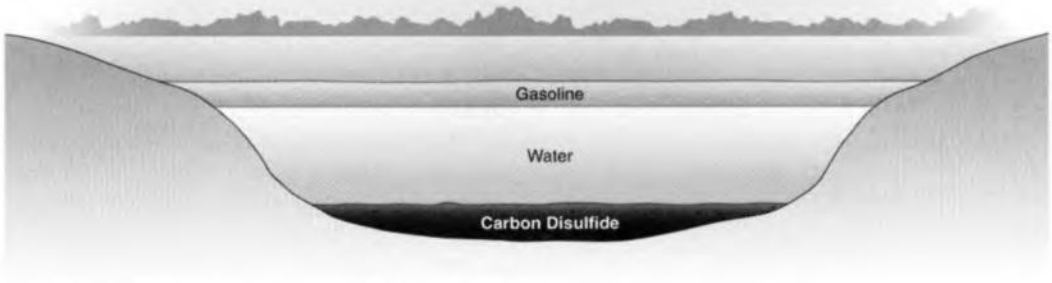



Figure 2-6 Gasoline will float on water, whereas carbon disulfide will not.

water is gently applied to a puddle of carbon disulfide, the water will rest on top and cover the puddle completely.

## Water Solubility

When discussing the concept of specific gravity, it is also necessary to determine if a chemical will mix with water. Water solubility describes the ability of a substance to dissolve in water. Water is the predominate agent used to extinguish fire, but when you are dealing with chemical emergencies, it may not always be the best and safest choice to mitigate the situation. That's because water is a tremendously aggressive solvent and has the ability to react violently with certain chemicals.

Concentrated sulfuric acid, metallic sodium, and magnesium are just a few examples of substances that will adversely react with water. If water is applied to burning magnesium, for example, the heat of the fire will break apart the water molecule, creating an explosive reaction. Adding water to sulfuric acid would be like throwing water on a pan full of hot oil—popping and spattering may occur.

In other circumstances, water can be a friendly ally when you are attempting to handle a chemical emergency. Depending on the chemical involved, fog streams operated from handlines may knock down vapor clouds. Additionally, heavier-than-water flammable liquids can be extinguished by gently applying water to the surface of the liquid. In some cases, water may be an effective way to dilute a chemical, thereby rendering it less hazardous.

## Corrosivity (pH)

Corrosivity is the ability of a material to cause damage (on contact) to skin, eyes, or other parts of the body. The technical definition, as found in the U.S. Code of Federal Regulations, includes the language, "destruction or irreversible damage to living tissue at the site of contact." Such materials are often also damaging to clothing, rescue equipment, and other physical objects in the environment.

Corrosives are a complex group of chemicals that should not be taken lightly. The tens of thousands of corrosive chemicals used in general industry, semiconductor manufacturing, and biotechnology can be further categorized into two classes: acid and base Figure 2-7.

There are number of technical ways to describe the acidity or alkalinity of a particular solution, but the most common

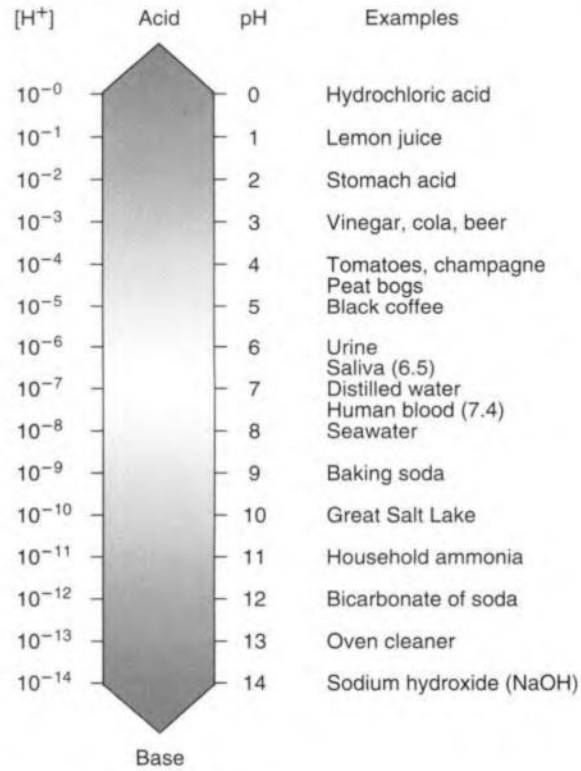



Figure 2-7 The pH scale.

Figure 2-8 An acid.

Figure 2-9 A base.

way to define them is by their pH. In simple terms, you can think of pH as the "**p**ower of **H**ydrogen." Essentially, pH is an expression of the measurement of the presence of dissolved hydrogen ions ($H^+$) in a substance. When thinking about pH from a field perspective, this value can be viewed as a measurement of corrosive strength, which can loosely be translated into a certain degree of hazard. In simple terms, we can use pH to judge how aggressive a particular corrosive might be. To assess that hazard, you must understand the pH scale.

How do we determine pH in the field? One method is to use specialized pH test paper. You can also obtain this information from the MSDS, or call for a specialized hazardous materials response team to determine the pH level of a chemical. Hazardous materials technicians have more specialized ways of determining pH and may be a useful resource when responders are handling corrosive incidents.

Common acids, such as sulfuric, hydrochloric, phosphoric, nitric, and acetic (vinegar) acids, have a predominate amount of hydrogen ions ($H^+$) in the solution and, therefore, will have pH values less than 7 Figure 2-8 ▲. Chemicals that are considered to be bases, such as sodium and potassium hydroxide, sodium carbonate, and ammonium hydroxide, have a predominate amount of hydroxide ($OH^-$) ions in the solution and will have pH values greater than 7 Figure 2-9 ▶.

The middle of the pH scale (7) is where a chemical is considered to be neutral—that is, neither acidic nor basic. A pH of 7 is considered "neutral" because the concentration of hydrogen ions ($H^+$) in such a material is exactly equal to the concentration of hydroxide ($OH^-$) ions produced by dissociation of the water. At this value, a chemical will not harm human tissue.

Generally, pH values of 2.5 or less, and those of 12.5 or greater, are considered to be strong. In practical terms, this designation means that strong corrosives (acids and bases) will react more aggressively with metallic substances such as steel and iron; they will cause more damage to unprotected skin; they will react more adversely when contacting other chemicals; and they may react violently with water.

At the awareness operations level, it is critical to understand that incidents involving corrosives may not be as straightforward as other types of chemical emergencies. The materials themselves are more complicated and, in fact, the tactics employed to deal with them could be outside your scope of responsibilities.

## Toxic Products of Combustion

Toxic products of combustion are the hazardous chemical compounds released when a material decomposes under heat. Recall that the process of combustion is a chemical reaction and, like other reactions, will generate a given amount of by-products. You are well aware of the smoke produced by a structure fire, but have you really thought about what's in the smoke, or taken a moment to think about the toxic gases that are liberated during a residential structure fire?

An easy way to think about this issue is to apply a phrase long used in the world of computers: "garbage in, garbage out." This phrase reflects the idea that whatever objects are involved in the fire (chairs, tables, and sofas, for example) will break down in the heat and release a host of chemical by-products in the smoke. In short, the toxic gases and other chemical substances found in the smoke will be determined by what is burning. To that end, smoke is not "just smoke"—it is unique, to some degree, in each and every fire.

Notable substances found in most fire smoke include soot, carbon monoxide, carbon dioxide, water vapor, formaldehyde, cyanide compounds, and many oxides of nitrogen. Each of these substances is unique in its chemical make-up and most are toxic to humans, even in small doses.

For example, carbon monoxide affects the ability of the human body to transport oxygen. When it is present in the body in excessive amounts, the red blood cells cannot get oxygen to the other cells of the body and, subsequently, a person will die from tissue asphyxiation. Cyanide compounds also adversely affect oxygen uptake in the body and are often a cause

of civilian death in structure fires. Formaldehyde is found in many plastics and resins; it is one of the many components of smoke that causes eye and lung irritation. The oxides of nitrogen, which include nitric oxide, nitrous oxide, and nitrogen dioxide, are deep lung irritants that may cause a serious medical condition called pulmonary edema (fluid build-up in the lungs).

## Radiation

Most fire fighters have not been trained on the finer points of handling incidents involving radioactive materials and, therefore, have many misconceptions about radiation. Radiation is energy transmitted through space in the form of electromagnetic waves or energetic particles.

Fundamentally, you should understand that you cannot escape radiation. It is all around you. During the course of your life, you will receive radiation from the sun and the soil, or by having an x-ray. Radiation is everywhere and has been around since the beginning of time. Our focus here, however, is not background radiation—the kind of radiation you received from the sun or the soil—but rather the occupational exposures encountered in the field. For the most part, the health hazards posed by radiation are a function of two factors:

- The amount of radiation absorbed by your body has a direct relationship to the degree of damage done.
- The exposure time to the radiation will ultimately affect the extent of the injury.

### Responder Safety Tips

Always consider the origin of any fire encountered. The conclusions you reach about the fire's source may require evacuating affected citizens, prompt you to employ unique tactics, or help you better understand and provide emergency medical care to civilians or your own personnel.

The periodic table of elements illustrates all the known elements that are found in all the chemical compounds on the face of the Earth Figure 2-10. Those elements, in turn, are made up of atoms. In the nucleus of those atoms are protons (positive [+] electrical charge) and neutrons (no electrical charge). Orbiting the nucleus are electrons (negative [–] electrical charge).

All stable atoms of any given element will have the same number of protons and neutrons in their nucleus. Those same elements, however, are prone to having an imbalance in the numbers of protons and neutrons. This variation in the number of neutrons creates a radioactive isotope of the element. Carbon-14, for example, is a radioactive isotope of carbon because of the imbalance in the numbers of protons and neutrons found in the nucleus of carbon-14. You'll notice on the periodic table of elements that stable carbon (C) has an atomic mass of 12. Carbon-14 illustrates a different mass which shows

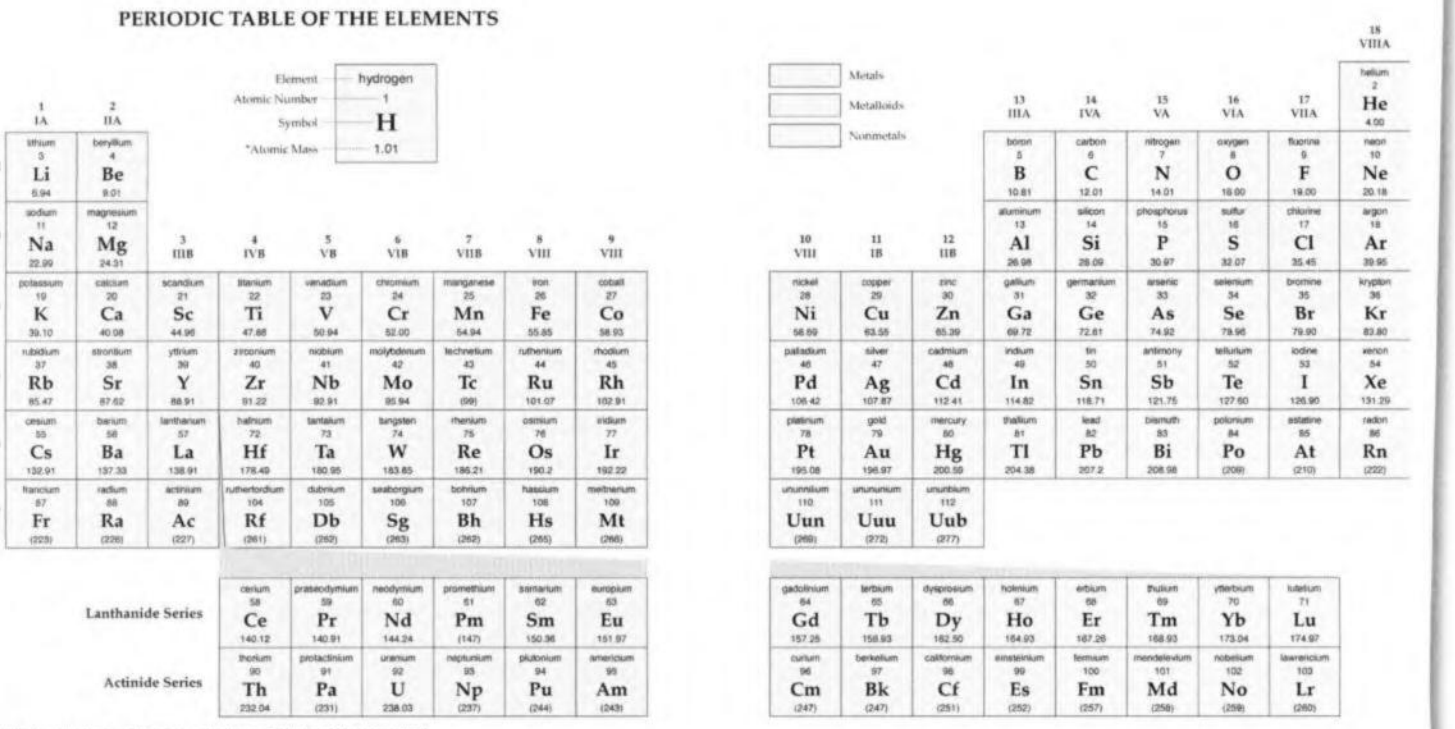



Figure 2-10 The periodic table of elements.

**Responder Tips**

Isotopes are atoms with the *same number* of protons but *different numbers* of neutrons.

its imbalance of protons and neutrons. Other examples include sulfur-35 and phosphorus-32, which are radioactive isotopes of sulfur and phosphorus, respectively.

Radioactivity is the natural and spontaneous process by which unstable atoms (isotopes) of an element decay to a different state and emit or radiate excess energy in the form of particles or waves. Radioactive isotopes give off energy from the nucleus of an unstable atom in an attempt to reach a stable state. Typically, you will encounter a combination of alpha, beta, and gamma radiation. Each of these forms of energy given off by a radioactive isotope will vary in intensity, and consequently determine your efforts to reduce the exposure potential Figure 2-11.

Small radiation detectors are available that can be worn on turnout gear. These detectors sound an alarm when dangerous levels of radiation are encountered and alert responders to leave the scene and call for more specialized assistance.

### Alpha Particles

As mentioned previously, radiation stems from an imbalance in the number of protons and neutrons in the nucleus of an atom. Alpha radiation is a reflection of that instability. This form of radiation energy is produced when an electrically charged particle is given off by the nucleus of an unstable atom. Alpha particles have weight and mass; as a consequence, they 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 a HEPA filter on a simple respirator or by using a self-contained breathing apparatus (SCBA). HEPA (high-efficiency particulate air) filters catch particles down to 0.3-micron size—much smaller than a typical dust particle. Although protection from exposure to alpha particles is offered through HEPA filters and proper personal protection equipment (PPE), this type of radiation still poses a serious health risk if it enters into the body.

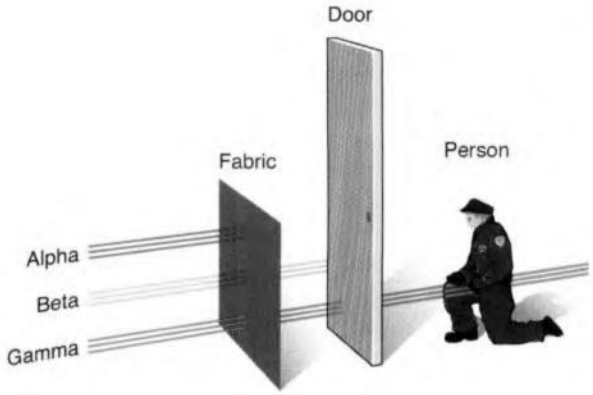



Figure 2-11 Alpha, beta, and gamma radiation.

**Responder Tips**

Radioactive *contamination* occurs when radioactive material is deposited on or in an object or a person. The release of radioactive materials into the environment can cause air, water, surfaces, soil, plants, buildings, people, or animals to become contaminated. A contaminated person has radioactive materials on or inside their body.

Radioactive materials give off a form of energy that travels in waves or particles. When a person is exposed to radiation, the energy penetrates the body. For example, when a person has an x-ray, he or she is said to be *exposed* to radiation.

*Source:* Centers for Disease Control and Prevention (CDC), *Fact Sheet: Radiation Emergencies*, May 2005.

### Beta Particles

Beta particles are more energetic than alpha particles and, therefore, pose a greater health hazard. Essentially, 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 10 to 15 feet in the open air. The beta particles themselves are not radioactive; rather, the radiation energy is generated by the speed at which the particles are emitted from the nucleus. Due to this phenomenon, beta radiation can break chemical bonds at the molecular level and cause damage to living tissue. This breaking of chemical bonds creates an ion; therefore, beta particles are considered ionizing radiation. Ionizing radiation has the capability to cause changes in human cells, which may ultimately lead to a mutation of the cell and become the root cause of cancer. Examples of ionizing radiation include x-rays and gamma rays.

Non-ionizing radiation comes from electromagnetic waves, which are capable of causing a disturbance of activity at

**Responder Safety Tips**

**Time–Distance–Shielding**

To reduce the effects of a radiation exposure, responders should understand the concept of time–distance–shielding (TDS). Think of TDS in this way: The less time you spend in the sun, the less chance you have of suffering a sunburn (*time*); the closer you stand to a fire, the hotter you will get (*distance*); and if you come inside during a rainstorm, you will stop getting wet (*shielding*).

the atomic level but do not have sufficient energy to break bonds and create ions. Typical non-ionizing waves include sound waves, radio waves, and microwaves.

Beta particles can redden (erythema) and burn skin; they can also be inhaled. Beta particles that are inhaled can directly damage the cells of the human body. Most solid objects can stop these particles, and your SCBA should provide adequate respiratory protection against them. Common beta emitters include tritium (luminous dials on gauges), iodine (medical treatment), and cesium.

#### Gamma Rays and Neutrons

Gamma radiation is the most energetic radiation responders may encounter. Gamma radiation differs from alpha and beta radiation in that it is not a particle ejected from the nucleus; rather, it is pure electromagnetic energy. A gamma ray has no mass and no electrical charge and travels at the speed of light. Gamma rays can pass through thick solid objects (including the human body) very easily and generally follow the emission of a beta particle. If the nucleus still has too much energy after ejecting beta particles, it may release a photon (a packet of pure energy) that takes the form of a gamma ray.

Like beta particles, gamma radiation is a form of ionizing radiation and can be deadly. Structural firefighting gear that includes SCBA will not protect you from gamma rays; if fire fighters are near the source of this type of radiation, they will be exposed. Typical sources of gamma radiation include cesium (cancer treatment and soil density testing at construction sites) and cobalt (medical instrument sterilization).

Neutrons are also penetrating particles found in the nucleus of the atom; they may be removed from the nucleus through nuclear fusion or fission. Neutrons themselves are not radioactive, but exposure to neutrons can create radiation, such as gamma radiation.

## Hazard, Exposure, and Contamination

When responders respond to hazardous materials incidents, it is vital that they understand those hazards so they can minimize their potential for exposure. To do so, responders must take the time to understand the problem they are facing, including the physical properties of the chemical and the release scenario. Responders must take initial precautions to protect themselves so they are able to mitigate the situation. This includes determining whether they have the right training, equipment, and protective gear to positively influence the outcome of the incident. For example, you cannot provide medical care to a contaminated victim if you are not properly protected against the contamination.

### Hazard and Exposure

In NFPA 472, *Standard for Competence of Responders to Hazardous Materials/Weapons of Mass Destruction Incidents*, a hazard is defined as a material capable of posing an unreasonable risk to health, safety, or the environment—that is, a material capable of causing harm. The same source defines exposure as the process by which people, animals, the environment, and equipment are subjected to or come into contact with a hazardous material.

### Contamination

When a chemical has been released and physically comes in contact with people, the environment, and everything around it, either intentionally or unintentionally, the residue of that chemical is called contamination. In some cases, the process of removing such contaminants is complex and requires a significant effort to complete. In other cases, the contamination is easily eliminated. Chapter 8, Mission-Specific Competencies: Technical Decontamination, covers the finer points of removing contaminants and decontaminating the responders and their gear. For now, simply understand that when a chemical escapes its container, you will need a system to safely and efficiently remove that chemical or reduce its physical hazard.

### Secondary Contamination

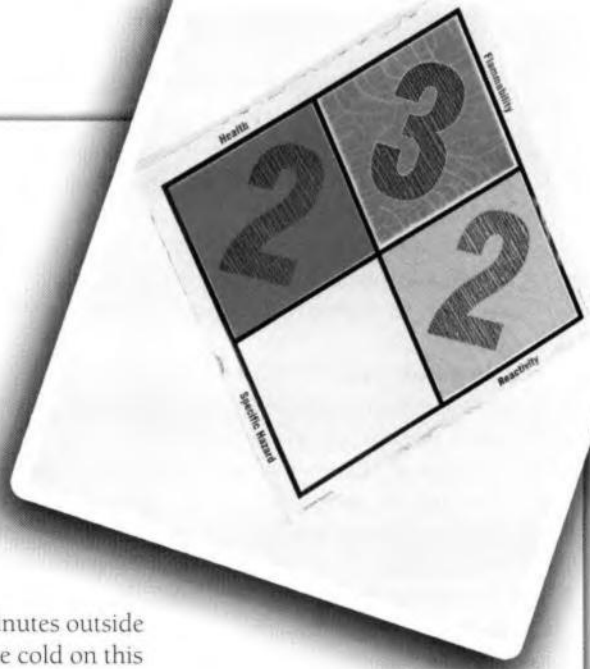
Secondary contamination, also known as cross-contamination, occurs when a person or object transfers the contamination or the source of contamination to another person or object by direct contact. In such cases, responders may become contaminated and subsequently handle tools and equipment, touch door handles or other responders, and spread the contamination. The possibility of spreading contamination brings up a point that all responders should understand: The cleaner responders stay during the response, the less decontamination they will have to do later. Many responders have the misperception that PPE is worn to enable you to contact the product at will. In fact, quite the opposite is true: PPE, including specialized chemical protective gear, is worn to protect you in the event that you cannot avoid product contact. The less contamination encountered or spread, the easier the decontamination will be.

## Types of Hazardous Materials: Weapons of Mass Destruction

In recent years, weapons of mass destruction (WMD) have become a highly relevant topic for responders. WMD represent a real threat in the United States, and each responder should have a basic knowledge of those potential threats. To that end, this section briefly addresses the threats posed by nerve, blister, blood, and choking agents, and other potential hazards associated with various irritant materials.

WMD events can be complex, and the harm inflicted during such incidents may be the result of several factors—nerve agents dispersed by explosions, radioactive contamination spread by the detonation of conventional explosives (so-called dirty bombs), and so on. Generally speaking, the damages caused by a terrorist attack or any other hazardous materials incident can be broadly classified into seven categories, best remembered by the mnemonic TRACEMP:

# Voices *of* Experience




It was so cold on that January morning in central Canada that a mere 5 minutes outside transformed my turnout gear into 25 pounds of crackling cellophane. The cold on this particular morning had the added complication of a thick blanket of "ice fog." The low visibility caused by the thick fog was the reason we found ourselves responding to a two-vehicle highway accident.

On arrival at the scene, we quickly determined that a semi-trailer carrying a full load of a highly volatile petroleum-based liquid had accidentally driven too close to another large vehicle. The two vehicles had rubbed the sides of their trailers together at a speed of about 30 miles per hour, causing about 20 feet of "tearing and creasing" along the side of the trailer containing the volatile liquid. At the scene, we noticed a puddle of product with about a 10-foot radius on the ground.

*"Different atmospheric conditions at this accident would have spurred us to different initial actions."*

Different atmospheric conditions at this accident would have spurred us to different initial actions. In this case, it was so cold that the liquid was unable to generate any significant vapors that could cause immediate concerns about ignition outside the product's immediate area. Our captain recognized that the cold weather affected this product in specific ways and, therefore, decided on situation-specific actions and priorities that would provide reasonable safety for all responders and bystanders, prevent the leaking product from spreading, and enable us to work to safely offload the remaining product to a suitable replacement container. On a hot day, the liquid would have been actively producing dangerous vapors, changing our initial actions. In that case, our priorities would have involved removal of ignition sources through isolation of the area as well as aggressive vapor suppression.

Changing factors, such as weather conditions and the environment immediately surrounding the affected area, will affect the properties and effects of hazardous materials. It is critical to gather as much information as possible about the hazard to accurately determine your initial actions and priorities.

Ray Unrau
Saskatoon Fire and Protective Services
Saskatoon, Saskatchewan

- **Thermal:** Heat created from intentional explosions or fires, or cold generated by cryogenic liquids.
- **Radiological:** Radioactive contamination from dirty bombs; alpha, beta, and gamma radiation.
- **Asphyxiation:** Oxygen deprivation caused by materials such as nitrogen; tissue asphyxiation from blood agents.
- **Chemical:** Injury and death caused by the intentional release of toxic industrial chemicals, nerve agents, vesicants, poisons, or other chemicals.
- **Etiological:** Illness and death resulting from biohazards such as anthrax, plague, and smallpox; hazards posed by bloodborne pathogens.
- **Mechanical:** Property damage and injury caused by explosion, falling debris, shrapnel, firearms, explosives, and slips, trips, and falls.
- **Psychogenic:** The mental harm from being potentially exposed to, contaminated by, and even just being in close proximity to an incident of this nature.

## Nerve Agents

Nerve agents pose a significant threat to civilians and responders alike. The main threat stems from the ability of a nerve agent to enter the body through the lungs or the skin and then systemically affect the function of the human body. Nerve agents, like many common pesticides, disrupt the central nervous system, possibly causing death or serious impairment.

The human central nervous system is laid out much like the electrical wiring in a house. The brain serves as the main panel. The wires—that is, the nerves—go to muscles, organs, glands, and other critical areas of the body. When a nerve agent enters the body, it affects the body's ability to transact nerve impulses at the junction points between nerves and muscles, nerves and vital organs, and nerves and glands. Subsequently, those critical areas will not function properly and associated bodily functions will be affected. For example, sarin is a water-like liquid nerve agent that is primarily a vapor hazard.

Signs and symptoms of nerve agent exposure may include pinpoint pupils, tearing of the eyes, twitching muscles, loss of bowel and bladder control, and slow or rapid heartbeat. Mild exposures may result in mild symptoms and include some or all of the symptoms listed above. Significant exposures may result in rapid death, serious impairment, or a more pronounced manifestation of symptoms. The bottom line is that an exposure to a nerve agent is not an automatic death sentence. Much like the case of radiation exposure, the dose absorbed is directly correlated with the degree of damage done and the symptoms presented by the victim.

Recognition of the signs and symptoms of a nerve agent exposure is vital in determining the presence of such a threat. Nerve agents in general are reported to have fruity odors. In many cases, responders will not have the specialized detection devices that are necessary to identify the presence of a nerve agent exposure; the symptoms presented by the victims should tip them off, however. To that end, the mnemonic SLUDGEM briefly summarizes some of the more common signs and symptoms of nerve agent exposure:

**S:** Salivation
**L:** Lacrimation (tearing)
**U:** Urination
**D:** Defecation
**G:** Gastric disturbance
**E:** Emesis (vomiting)
**M:** Miosis (constriction of the pupil)

Many times, nerve agents are incorrectly referred to as nerve gas. Nerve agents are liquids, not gases, and each one evaporates at a different rate. Sarin, for example, is a water-like liquid that evaporates more easily than VX, which is a thick, oily liquid.

VX is the most toxic of the weapons-grade nerve agents. It also has the most persistence (continued presence). Other nerve agents include soman and tabun. The organophosphate and carbamate classes of pesticides are similar to the weapons-grade nerve agents, but are less toxic in general terms.

## Blister Agents

Blister agents (also known as vesicants) have the ability to cause blistering of the skin. Common blister agents include sulfur mustard and Lewisite, which interact in unique ways with the human body.

Sulfur mustard was first used as a weapon in World War I. Chemical casualties suffered horrific injuries to the skin and lungs; in some cases, those exposures proved fatal. Although sulfur mustard is commonly referred to as mustard gas, it is more typically found in a liquid state. This chemical is colorless and odorless when pure. When mixed with other substances or otherwise impure, however, it can look brownish in color and smell like garlic or onions.

Exposures to sulfur mustard may not be immediately apparent. A victim may not experience pain or any other sign indicating current contact with this agent. Indeed, redness and blistering may not appear until 2 to 24 hours after exposure. Once the blistering does occur, skin decontamination will not reduce its effects Figure 2-12. If sulfur mustard exposure is suspected, immediate skin decontamination is indicated. Early skin decontamination may reduce the effects of exposure.

Figure 2-12 Blister agent exposure.

Sulfur mustard produces injuries similar to second- and third-degree thermal burns. In cases involving mild skin exposures, victims typically make a complete recovery. Inhalation exposures are much more serious, with the damage to lung tissues sometimes resulting in permanent respiratory function impairment. Additionally, sulfur mustard is very persistent in the environment. When it is released in this way, it can remain intact, sticking to the ground or other surfaces, for several days.

Lewisite has many of the same characteristics as sulfur mustard.

Lewisite, however, contains arsenic; thus, when it is absorbed by the skin, this blister agent may produce some symptoms specific to arsenic poisoning, such as vomiting and low blood pressure. Unlike sulfur mustard, Lewisite exposures to the skin will produce immediate pain. Lewisite is a colorless-to-dark brown oily brown liquid that smells of geraniums. If a Lewisite exposure is suspected, immediate and aggressive skin decontamination is indicated. Like sulfur mustard, Lewisite does not occur naturally in the environment and is considered to be a chemical warfare agent.

### Blood Agents

Blood agents are chemicals that, when absorbed by the body, interfere with the transfer of oxygen from the blood to the cells. Cyanide compounds, including hydrogen cyanide and cyanogen chloride, prevent the body from using oxygen. Victims exposed to high levels of cyanide, for example, could be placed on supplemental oxygen but still not survive the exposure. The cause of death in such cases is not a lack of oxygen, but rather the inability of the body to use the available oxygen effectively.

The main route of exposure to cyanide compounds is through the lungs, but many of these agents can also be ingested or absorbed through the skin. Hydrogen cyanide has a reported odor of bitter almonds, but approximately 60 percent of the general population cannot detect the presence of hydrogen cyanide by smell. Thus, because the odor threshold and the amount of cyanide that would be lethal are very close, odor alone cannot be used to detect dangerous amounts of hydrogen cyanide. By contrast, cyanogen chloride, because of the chlorine atom within the chemical compound, has a much more irritating and pungent odor.

Typical signs and symptoms of cyanide exposure include vomiting, dizziness, watery eyes, and deep and rapid breathing. High concentrations lead to convulsions, inability to breathe, loss of consciousness, and death.

### Choking Agents

Choking agents are predominantly designed to inhibit breathing and are typically intended to incapacitate rather than to kill; nevertheless, death and serious injuries from these agents are possible. The nature of choking agents (extremely irritating odor) alerts potential victims to their presence and allows for escape from the environment when possible. Commonly recognized choking agents include chlorine, phosgene, and chloropicrin.

Each of these substances is associated with a specific odor. Chlorine smells like a swimming pool, whereas phosgene and chloropicrin have been reported to smell like freshly mown grass or hay. In either case, the odors are noticeable and, in many cases, strong enough and irritating enough to alert victims to the presence of an unusual situation.

In the event of a significant exposure, the main threat from these materials is pulmonary edema (also known as dry drowning, because the victim's lungs fill with fluid). When inhaled, choking agents damage sensitive lung tissue and cause fluid to be released. The excess fluid results in chemically induced pneumonia, which could end up being fatal. Additionally, choking agents act as skin irritants; they can cause mild to moderate skin irritation and significant burning when victims are exposed to them in high concentrations.

### Irritants (Riot Control Agents)

Irritants (also known as riot-control agents) include substances, such as mace, that can be dispersed to briefly incapacitate a person or groups of people. Chiefly, irritants cause pain and a burning sensation to exposed skin, eyes, and mucous membranes. The onset of symptoms occurs within seconds after contact and lasts several minutes to several hours, usually with no lasting effects. Irritants can be dispersed from canisters, handheld sprayers, and grenades.

From a terrorism perspective, irritants may be employed to incapacitate rescuers or to drive a group of people into another area where a more dangerous substance can be released. Of all the groups of WMD, irritants pose the least amount of direct danger in terms of toxicity. Exposed patients can be decontaminated with clean water, and the residual effects of the exposure are rarely significant. Responders are likely to encounter these agents when they respond to calls in which law enforcement personnel have used these agents for riot control or suspect apprehension. It is important for responders to know which specific agents are used by local law enforcement agencies for such purposes and to identify any specific decontamination techniques recommended for use with those agents.

### Convulsants

Chemicals classified as convulsants are capable of causing convulsions or seizures when they are absorbed by the body. Chemicals that fall into this category include nerve agents such as sarin, soman, tabun, VX, and the organophosphate and carbamate classes of pesticides. These substances interfere with the central nervous system and disrupt normal transmission of neuromuscular impulses throughout the body. Examples of pesticides that are capable of functioning as convulsants include parathion, aldicarb, diazinon, and fonofos.

When dealing with these materials, it is important to identify their presence and to avoid breathing in their vapors or allowing the liquid to contact your skin. In some cases, even a small exposure can be fatal.

## Harmful Substances' Routes of Entry into the Human Body

For a chemical or other harmful substance to injure a person, it must first get into the individual's body. Throughout the

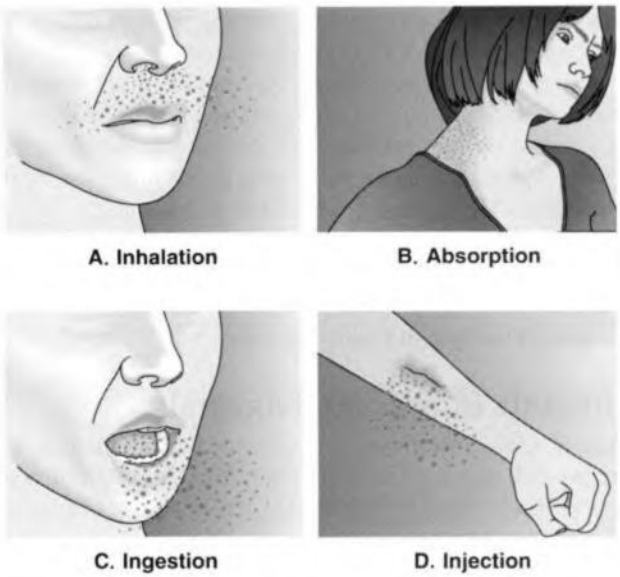



Figure 2-13 The four ways a chemical substance can enter the body. **A.** Inhalation. **B.** Absorption. **C.** Ingestion. **D.** Injection.

Figure 2-14 Air-purifying respirators offer some degree of protection against airborne chemical hazards.

course of his or her service career, a responder will inevitably be bombarded by harmful substances such as diesel exhaust, bloodborne pathogens, smoke, and accidentally and intentionally released chemicals. Fortunately, most of these exposures are not immediately deadly. Unfortunately, repetitive exposures to these materials may have negative health effects after a 20-year career. To protect yourself now and give yourself the best shot at a healthy retirement, it is important to understand some basic concepts about toxicology. Chemical substances can enter the human body in four ways Figure 2-13.

- Inhalation: Through the lungs
- Absorption: By permeating the skin
- Ingestion: Via the gastrointestinal tract
- Injection: Through cuts or other breaches in the skin

Toxicology is the study of the adverse effects of chemical or physical agents on living organisms. The following sections discuss these agents' potential routes of entry into the human body and methods used to protect against these agents.

## Inhalation

Inhalation exposures occur when harmful substances are brought into the body through the respiratory system. The lungs are a direct point of access to the bloodstream, so they can quickly transfer an airborne substance into the bloodstream.

The entire respiratory system is vulnerable to attack from most hazardous materials and WMD, corrosive materials such as chlorine and ammonia, solvent vapors such as gasoline and acetone, superheated air, and any other material finding its way into the air. In addition to gases and vapors, small particles of dust and smoke can become lodged in sensitive lung tissue, causing substantial irritation.

Given these facts, it is imperative that responders wear their respiratory protection when operating in the presence of airborne contamination. Fortunately, fire fighters have ready access to an excellent form of respiratory protection—namely, the positive-pressure, open-circuit SCBA. This equipment is by far the single most important piece of PPE that fire fighters have at their disposal. Sometimes fire fighters may need to use other forms of respiratory protection depending on the specific respiratory hazard they are facing while performing a given task. For example, full-face and half-face air purifying respirators (APRs) offer specific degrees of protection if the chemical hazard present is known and the appropriate filter canister is used Figure 2-14.

Respirators do not provide oxygen or breathing air, however. Thus, if the oxygen content of the work area is low, respirators are not a viable option. According to the Occupational Health and Safety Administration (OSHA), any work environment containing less than 19.5% oxygen is considered to be oxygen deficient and will require the use of an SCBA or supplied air respirator. Another drawback to APRs is that filters can be costly and are often needed in large quantities, depending on the nature of the response.

Respirators are lighter than SCBA, are more comfortable to wear, and usually allow longer work periods because they are not dependent on a limited source of breathing air. SCBA certainly offer a higher level of respiratory protection, but in the right circumstances, APRs may represent a viable form of respiratory protection.

When considering protection against airborne contamination, it is important to understand the origin, concentration, and potential impact of the contamination relative to the oxygen levels in the area. In short, the appropriate type of respiratory protection is determined by looking at the overall situation, including the nature of the contaminant. In some cases, the anticipated particle size of the contamination may dictate the level of respiratory protection employed Table 2-3.

Anthrax spores offer an excellent example to illustrate this point. Weaponized anthrax spores typically vary in size from

**Table 2-3 Particle Sizes of Common Types of Respiratory Hazards**

| | |
|---|---|
| **Fume** | <1 micron |
| **Smoke** | <1 micron–1 micron |
| **Dust** | 1 micron+ |
| **Fog** | <40 microns |
| **Mist** | >40 microns |

0.5 micron to 1 micron. Based on that size range, a typical full-face APR with a nuisance dust filter would not offer sufficient protection against this hazard. Anyone operating in an area contaminated with anthrax should wear SCBA or, at a minimum, an APR with HEPA filtration (which offers protection from 0.3-micron or larger particles).

Anthrax exposures also illustrate another important pair of terms and definitions that responders should understand: infectious and contagious. Anthrax is a pathogenic microorganism capable of causing an illness (infectious). A person with an illness caused by an anthrax exposure, however, is not capable of passing it along to another person (contagious). In other words, anthrax is not contagious. Conversely, smallpox can be both infectious and contagious, which is why this pathogen poses such a high risk in the event of an outbreak.

Now consider this scenario: A container of gaseous helium is leaking inside a poorly ventilated storage room. Helium is nonflammable; the main threat it poses is the possibility of oxygen deficiency. In this case, SCBA is the appropriate type of respiratory protection based on the anticipated hazard. In many cases, hazardous materials technicians may need to respond to incidents; they will use air-monitoring devices to characterize the work area prior to entry. When this step is taken, choices of respiratory protection are based on more definitive information.

Particle size also determines where the inspired contamination will eventually end up. The larger particles that make up visible mists will be captured in the nose and upper airway, for example, whereas smaller particles may work their way deeper into the lung Table 2-4.

Respiratory protection is one of the most important components of any PPE. In all cases where airborne contamination is encountered, take the time to understand the nature of the threat, evaluate the respiratory protection available, and decide if it provides adequate protection. When protecting the lungs, "good enough" is not an option. Chapter 7, Mission-Specific Competencies: Personal Protective Equipment, addresses the concept of chemical PPE and describes how respiratory protection fits into the "big picture" of remaining safe at chemical incidents.

**Table 2-4 Location of Respiratory Trapping by Particle Size**

| | |
|---|---|
| **>7 microns** | Nose |
| **5–7 microns** | Larynx |
| **3–5 microns** | Trachea and bronchi |
| **2–3 microns** | Bronchi |
| **1–2.5 microns** | Respiratory bronchioles |
| **0.5–1 micron** | Alveoli |

## Absorption

The skin is the largest organ in the body and is susceptible to the damage inflicted by a number of substances. In addition to serving as the body's protective shield against heat, light, and infection, the skin helps to regulate body temperature, stores water and fat, and serves as a sensory center for painful and pleasant stimulation. Without this important organ, human beings would not be able to survive.

When discussing chemical exposures, however, absorption is not limited only to the skin. Absorption is the process by which substances travel through body tissues until they reach the bloodstream. The eyes, nose, mouth, and, to a certain degree, the intestinal tract are also part of the equation. The eyes, for example, will absorb a high amount of liquid and vapor that come into contact with these sensitive tissues. This absorption is particularly problematic because the eyes connect directly to the optic nerve, which allows the chemical to follow a direct route to the brain and the central nervous system.

Although the skin functions as a shield for the body, that shield can be pierced by a number of chemicals. Aggressive solvents such as methylene chloride (found in paint stripper), for example, can be readily absorbed through the skin. A secondary hazard associated with this chemical occurs when the body attempts to metabolize the substance after it is absorbed. A byproduct of that metabolism reaction is carbon monoxide, a cellular asphyxiant. Asphyxiants are substances that prevent the body (at the cellular level) from using oxygen, thereby causing suffocation. In this scenario, the initial chemical is broken down to form another substance that is potentially a greater health hazard than the original chemical. Methylene chloride is also suspected to be a human cancer-causing agent (carcinogen).

Absorption hazards are not limited to solvents. Hydrofluoric acid, for example, poses a significant threat to life when it is absorbed through the skin. This unique corrosive has the ability to bind with certain substances in the body (predominately calcium). Secondary health effects occurring after exposure can include muscular pain and potentially lethal cardiac arrhythmias.

In the field, responders must constantly evaluate the possibility of chemical contact with their skin and eyes. In many cases, structural firefighting turnout gear provides little or no protection against liquid chemicals. Consult the *Emergency Response Guidebook* or an MSDS for response guidance when deciding whether turnout gear is appropriate for the hazard you are facing. In the event the turnout gear does not offer adequate protection, responders may have to increase their level of protection to include specialized chemical-protective clothing.

## Ingestion

In addition to absorption through the skin, chemicals can be brought into the body through the gastrointestinal tract, by the

process of ingestion. The water, nutrients, and vitamins the body requires are predominately absorbed in this manner. For example, at a structure fire, fire fighters generally have an opportunity to rotate out of the building for rest and refreshment and may not take the time to wash up prior to eating or drinking. This leads to a high probability of spreading contamination from the hands to the food and subsequently to the intestinal tract. If you do not think about every situation where you might become exposed, you may put yourself in harm's way.

### Injection

Chemicals brought into the body through open cuts and abrasions qualify as injection exposures. To protect yourself from this route of exposure, begin by realizing when you will work in a compromised state. Any cuts or open wounds should be addressed before reporting for duty. If they are significant, you may be excluded from operating in contaminated environments. Open wounds act as a direct portal to the bloodstream and subsequently to muscles, organs, and other body systems. If a chemical substance comes in contact with this open portal, the health effects could be immediate and pronounced. Remember—intact skin is a good protective shield. Do not go into battle if your shield is not up to the task.

## Chronic and Acute Health Effects

A chronic health hazard (also known as a chronic health effect) is an adverse health effect that occurs gradually over time after long-term exposure to a hazard. Chronic health effects may appear either after long-term or chronic exposures or following multiple short-term exposures that occur over a shorter period. The exposures can involve all routes of entry into the body and may result in such health problems as cancer, permanent loss of lung function, or repetitive skin rashes. For example, inhaling asbestos fibers for years without respiratory protection can result in a form of lung cancer called asbestosis. This is an example of a target organ effect—chronic asbestos exposures target the lungs as the site of their damage.

Chemicals that pose a hazard to health after relatively short exposure periods are said to cause acute health effects. Such an exposure period is considered to be subchronic, with effects occurring either immediately after a single exposure or as long as several days or weeks after an exposure. Essentially, acute exposures are "right now" exposures that produce some observable conditions such as eye irritation, coughing, dizziness, and skin burns.

Skin irritation and burning after a dermal exposure to sulfuric acid would be classified as an acute health effect. Other chemicals, such as formaldehyde, are also capable of causing acute health effects. Among other things, formaldehyde is a sensitizer that is capable of causing an immune system response when it is inhaled or absorbed through the skin. This reaction is similar to other allergic reactions, in that the initial exposure produces mild health effects, but subsequent exposures cause much more severe reactions such as breathing difficulties and skin irritation. OSHA defines a sensitizer as a chemical that causes a substantial proportion of exposed people or animals to develop an allergic reaction in normal tissue after repeated exposure to the chemical.

Toxicity is a measure of the degree to which something is toxic or poisonous. This term can also refer to the adverse effect(s) a substance may have on a whole organism, such as a human (or a bacterium or a plant), or to a substructure such as a cell or a specific organ such as the liver, kidneys, or lungs. To understand the risks posed by a material's toxicity, emergency responders must consider the physical and chemical properties of the substance causing the illness or injury, as well as the dose–response relationship that exists when a person is exposed to any substance. This important correlation refers to the response (signs, symptoms, illness, or injury) that a specific dose might provoke from the human body. The magnitude of the response depends on several factors, including the concentration of the hazardous substance and the duration of the exposure. The actual dose is the amount taken up by a person through one of the four routes of entry.

Cyanide, for example, is a harmful substance that can enter the body by all routes of entry. If cyanide gets into the body via the lungs, for example, it would be useful to understand at what airborne concentration (dose) the exposure might produce adverse health effects (response). To fully understand the threat, responders must be familiar with several health-related terms and definitions as they relate to airborne and dermal exposures. For example, the lethal dose (LD) of a material is a single dose that causes the death of a specified number of the group of test animals exposed by any route other than inhalation. The lethal concentration (LC) is defined as the concentration of a material in air that, on the basis of laboratory tests (inhalation route), is expected to kill a specified number of the group of test animals when administered over a specified period of time.

Several subcategories of LD and LC exist, each depicting a benchmark concentration of a particular exposure that will be harmful and/or fatal to a certain percentage of the test population. These values are commonly found in MSDS, electronic databases, and printed reference books. In most cases, these values are derived from animal studies, so the results may not exactly correspond to the levels/concentrations that would be harmful to humans.

The following overall descriptions of these benchmark values offer relative guidelines when it comes to determining potential levels of human toxicity. As mentioned earlier, many chemical substances on the market today have established LD or LC values. Typically, if the substance is a vapor or gas, it will be expressed as an LC value. If the substance poses a dermal threat or is harmful when ingested, its toxicity will be expressed as an LD value.

For any given substance, the LD is the lowest dosage per unit of body weight (typically stated in terms of milligrams per kilogram [mg/kg] of body weight) of a substance known to have resulted in fatality in a particular animal species. The median lethal dose ($LD_{50}$) of a toxic material is the dose required to kill half (50 percent) of the members of a tested population.

For example, the $LD_{50}$ of sodium cyanide (based on testing done on laboratory rats) is approximately 6.4 mg/kg. *$LD_{50}$ figures are frequently used as a general indicator of a substance's toxicity.* The $LD_{hi}$ or $LD_{100}$ is the absolute dose of a toxic material required to kill all (100 percent) of the members of a tested population.

The $LC_{lo}$ is the lowest lethal concentration of a material reported to cause death in a particular animal species, when administered via the inhalation route; it is the lowest lethal concentration for gases, dusts, vapors, and mists. The $LC_{50}$ is the concentration of a material in air that is expected to kill 50 percent of the group of a particular animal species when administered via the inhalation route. Some literature reports the $LC_{50}$ of carbon monoxide to be approximately 3700 parts per million (ppm) for a 1-hour exposure time frame. Carbon monoxide levels have been measured in working structure fires to approach 10,000 ppm—well above the $LC_{50}$. The $LC_{hi}$ or $LC_{100}$ is the absolute concentration of a toxic material required to kill all (100 percent) of the members of a tested population when the substance is administered via the inhalation route.

The values expressed above figure prominently in OSHA's view when it comes to identifying the relative toxicity of a particular substance. The following information reflects OSHA's view of exposure levels considered to be toxic and highly toxic.

The label *toxic*, as defined by OSHA 29 CFR 1910.1200, is assigned to any chemical that falls in one of these three categories:

- A chemical that has a $LD_{50}$ of more than 50 mg/kg but not more than 500 mg/kg of body weight when administered orally to albino rats weighing between 200 and 300 g each.
- A chemical that has a $LD_{50}$ of more than 200 mg/kg but not more than 1000 mg/kg of body weight when administered by continuous contact for 24 hours (or less if death occurs within 24 hours) with the bare skin of albino rabbits weighing between 2 and 3 kg each.
- A chemical that has a $LC_{50}$ in air of more than 200 ppm but not more than 2000 ppm by volume of gas or vapor, or more than 2 mg/L but not more than 20 mg/L of mist, fume, or dust, when administered by continuous inhalation for 1 hour (or less if death occurs within 1 hour) to albino rats weighing between 200 and 300 g each.

OSHA 29 CFR 1910.1200 describes *highly toxic* materials as follows.

- A chemical that has a $LD_{50}$ of 50 mg/kg or less of body weight when administered orally to albino rats weighing between 200 and 300 g each.
- A chemical that has a $LD_{50}$ of 200 mg/kg or less of body weight when administered by continuous contact for 24 hours (or less if death occurs within 24 hours) with the bare skin of albino rabbits weighing between 2 and 3 kg each.
- A chemical that has a $LC_{50}$ in air of 200 ppm by volume or less of gas or vapor, or 2 mg/L or less of mist, fume, or dust, when administered by continuous inhalation for 1 hour (or less if death occurs within 1 hour) to albino rats weighing between 200 and 300 g each.

# Wrap-Up

## Chief Concepts

- The most fundamental of all actions is the ability to observe the scene and understand the problem you are facing. Think before you act—it could save your life!
- An important first step in understanding the hazards of any chemical is identifying the state of matter and defining whether the substance is a solid, liquid, or gas.
- A critical step in comprehending the nature of the release is identifying the reason(s) why the containment vessel failed.
- Chemical change is not the same thing as physical change. Physical change is a change in state; chemical change describes the ability of a substance to undergo a transformation at the molecular level, usually with a release of some form of energy.
- There are many critical characteristics of flammable liquids, and you should be familiar with each of them.
- When responders respond to hazardous materials incidents, they must fully understand the hazards to minimize the potential for exposure.
- Avoid contamination whenever possible—it will reduce the likelihood of harmful exposures.
- Chemicals can enter the body in four ways: inhalation, absorption, ingestion, and injection.
- Nerve agents, blister agents, blood agents, choking agents, irritants, and convulsants are examples of hazardous materials that may be used as WMD.
- Irritants such as mace cause immediate irritation of the skin, eyes, and mucous membranes.
- Equipment such as HEPA filtration on APR cartridges and SCBA can protect lungs from small particulates such as smoke, dust, and fumes.
- Chronic health effects may occur after years of exposure to hazardous materials. Wear all protective gear to minimize the impacts of repeated exposures.

## Hot Terms

Absorption The process of applying by which substances travel through body tissues until they reach the bloodstream.

Acid A material with a pH value less than 7.

Acute exposure A "right now" exposure that produces observable signs such as eye irritation, coughing, dizziness, and skin burns.

Acute health effects Health problems caused by relatively short exposure periods to a harmful substance that produces observable conditions such as eye irritation, coughing, dizziness, and skin burns.

Alpha particle A type of radiation that quickly loses energy and can travel only 1 or 2 inches from its source. Clothing or a sheet of paper can stop this type of energy. Alpha particles are not dangerous to plants, animals, or people unless the alpha-emitting substance has entered the body.

Anthrax An infectious disease spread by the bacterium *Bacillus anthracis;* typically found around farms, infecting livestock.

Asphyxiant A material that causes the victim to suffocate.

Base A material with a pH value greater than 7.

Beta particle A type of radiation that is capable of travelling 10 to 15 feet from its source. Heavier materials, such as metal and glass, can stop this type of energy.

BLEVE Boiling liquid/expanding vapor explosion; an explosion that occurs when pressurized liquefied materials (propane or butane, for example) inside a closed vessel are exposed to a source of high heat.

Blister agent A chemical that causes the skin to blister; also known as a vesicant.

Blood agent Chemicals that interfere with the utilization of oxygen by the cells of the body. Cyanide is an example of a blood agent.

Boiling point The temperature at which a liquid will continually give off vapors in sustained amounts and, if held at that temperature long enough, will eventually turn completely into a gas.

Carcinogen A cancer-causing agent.

Chemical and physical properties Measurable characteristics of a chemical, such as its vapor density, flammability, corrosivity, and water reactivity.

Chemical reactivity The ability of a chemical to undergo an alteration in its chemical make-up, usually accompanied by a release of some form of energy.

Chlorine A yellowish gas that is approximately 2.5 times heavier than air and slightly water soluble. Chlorine has many industrial uses but also damages the lungs when it is inhaled; it is a choking agent.

Choking agent A chemical designed to inhibit breathing and typically intended to incapacitate rather than kill its victims.

Chronic exposure Long-term exposure, occurring over the course of many months or years.

Chronic health hazard An adverse health effect occuring after a long-term exposure to a substance.

Combustible The process of burning from a gaseous or vaporous state.

Contagious Capable of transmitting a disease.

Contamination The process of transferring a hazardous material from its source to people, animals, the environment, or equipment, all of which may act as carriers for the material.

Convulsant A chemical capable of causing convulsions or seizures when absorbed by the body. Chemicals that fall into this category include nerve agents such as sarin, soman, tabun, VX and the organophosphate and carbamate classes of pesticides.

Corrosivity The ability of a material to cause damage (on contact) to skin, eyes, or other parts on the body.

Cyanide compounds Blood agents that prevent the body from using the available oxygen effectively.

Expansion ratio A description of the volume increase that occurs when a liquid changes to a gas.

Exposure The process by which people, animals, the environment, and equipment are subjected to or come into contact with a hazardous material.

Fire point The temperature at which sustained combustion will occur. The fire point is usually only slightly higher than the flash point for most materials.

Flammable range An expression of a fuel/air mixture, defined by upper and lower limits, that reflects an amount of flammable vapor mixed with a given volume of air.

Flash point The minimum temperature at which a liquid or a solid releases sufficient vapor to form an ignitable mixture with air.

Gamma radiation A type of radiation that can travel significant distances, penetrating most materials and passing through the body. Gamma radiation is the most destructive type of radiation to the human body.

Hazard A material capable of posing an unreasonable risk to health, safety, or the environment; a material capable of causing harm.

HEPA (high-efficiency particulate air) 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.

Ignition (autoignition) temperature The minimum temperature at which a fuel, when heated, will ignite in air and continue to burn. Also called the autoignition temperature.

Infectious Capable of causing an illness by entry of a pathogenic microorganism.

Ingestion Exposure to a hazardous material by swallowing the substance.

Inhalation Exposure to a hazardous material by breathing the substance into the lungs.

Injection Exposure to a hazardous material by the substance entering cuts or other breaches in the skin.

Ionizing radiation Electromagnetic waves of such intensity that chemical bonds at the atomic level can be broken (creating an ion).

Irritant A substance (such as mace) that can be dispersed to briefly incapacitate a person or groups of people. Irritants cause pain and a burning sensation to exposed skin, eyes, and mucous membranes.

Lethal concentration (LC) The concentration of a material in air that, on the basis of laboratory tests (inhalation route), is expected to kill a specified number of the group of test animals when administered over a specified period of time.

Lethal dose (LD) A single dose that causes the death of a specified number of the group of test animals exposed by any route other than inhalation.

Lewisite A blister-forming agent that is an oily, colorless-to-dark brown liquid with an odor of geraniums.

Lower explosive limit (LEL) The minimum amount of gaseous fuel that must be present in the air for the air/fuel mixture to be flammable or explosive. Also referred to as the lower flammable limit (LFL).

Nerve agent A toxic substance that attacks the central nervous system in humans.

Neutrons Penetrating particles found in the nucleus of the atom that are removed through nuclear fusion or fission. Although neutrons are not radioactive, exposure to them can create radiation.

Non-ionizing radiation Electromagnetic waves capable of causing a disturbance of activity at the atomic level but do not have sufficient energy to break bonds and create ions.

Persistence The continued presence of a substance in the environment. Persistent chemicals are typically dense

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# Wrap-Up

oily substances with high molecular weights and low vapor pressures.

pH An expression of the amount of dissolved hydrogen ions ($H^+$) in a solution.

Physical change A transformation in which a material changes its state of matter—for instance, from a liquid to a solid.

Plague An infectious disease caused by the bacterium *Yersinia pestis*, which is commonly found on rodents.

Pulmonary edema Fluid build-up in the lungs.

Radiation The combined process of emission, transmission, and absorption of energy traveling by electromagnetic wave propagation between a region of higher temperature and a region of lower temperature.

Radioactive isotope A variation of an element created by an imbalance in the numbers of protons and neutrons in an atom of that element.

Radioactivity The spontaneous decay or disintegration of an unstable atomic nucleus accompanied by the emission of radiation.

Sarin A liquid nerve agent that is primarily a vapor hazard.

Secondary contamination The process by which a contaminant is carried out of the hot zone and contaminates people, animals, the environment, or equipment. Also referred to as cross-contamination.

Sensitizer A chemical that causes a large percentage of people or animals to develop an allergic reaction after repeated exposure.

Smallpox A highly infectious disease caused by the *Variola* virus.

Solvent A substance that dissolves another substance so as to make a solution.

Specific gravity The weight of a liquid as compared to water.

State of matter The physical state of a material—solid, liquid, or gas.

Sulfur mustard A clear, yellow, or amber oily liquid with a faint, sweet, odor of mustard or garlic that may be dispersed in an aerosol form. It causes blistering of exposed skin.

Target organ effect A situation in which specific bodily organs are typically affected by exposures to certain chemical substances.

Toxicity A measure of the degree to which something is toxic or poisonous. Toxicity can also refer to the adverse effects a substance may have on a whole organism, such as a human (or a bacterium or a plant), or to a substructure such as a cell or a specific organ.

Toxicology The study of the adverse effects of chemical or physical agents on living organisms.

Toxic products of combustion Hazardous chemical compounds that are released when a material decomposes under heat.

TRACEMP An acronym to help remember the effects and potential exposures to a hazardous materials incident: thermal, radiation, asphyxiant, chemical, etiologic, mechanical, and psychogenic.

Upper explosive limit (UEL) The maximum amount of gaseous fuel that can be present in the air if the air/fuel mixture is to be flammable or explosive.

Vapor The gas phase of a substance, particularly of those substances that are normally liquids or solids at room temperatures.

Vapor density The weight of an airborne concentration (vapor or gas) as compared to an equal volume of dry air.

Vapor pressure For our purpose, the pressure associated with liquids held inside any type of closed container.

VX A thick, oily liquid that is the most toxic of the weapons-grade nerve agents.

Water solubility The ability of a substance to dissolve in water.

# Responder *in Action*

Your crew arrives at a biotechnology research company, where you find an 8-liter spill of acetonitrile in a laboratory. The scientist working in the laboratory dropped two glass containers, each containing 4 liters, shattering both on the tile floor. The chemical saturated both legs of the scientist's pants up to the knee. You find him sitting on a chair in an adjacent break room, still dripping wet from the spill. No decontamination has been performed. He is coughing and complains of a severe headache. One of the scientist's co-workers hands you an MSDS. Answer the following questions based on the selected information found on the MSDS.

**Chemical name:** ACETONITRILE
**Appearance:** Clear, colorless liquid
**Odor:** Similar to ether
**Flash point:** 36°F (2°C)
**Flammable range:**
Lower explosive limit (LEL): 4.4 percent
Upper explosive limit (UEL): 16.0 percent
**Solubility:** Miscible in water.
**Specific gravity:** 0.79
**pH:** No information found.
**Vapor density (air = 1):** 1.4
**Vapor pressure (mm Hg):** 73 @ 68°F (20°C)
**Evaporation rate (BuAc = 1):** 5.79
**Health effects:** Effects of overexposure are often delayed, possibly due to the slow formation of cyanide anions (negatively charged ions or atoms) in the body. These cyanide anions prevent the body from using oxygen and can lead to internal asphyxiation. Early symptoms may include nose and throat irritation, flushing of the face, and chest tightness.

1. Based on the information found on the MSDS, would the victim's signs and symptoms lead you to believe he requires immediate decontamination and medical treatment? If so, choose the following answer that best represents your next course of action.
   - **A.** The victim is not suffering any health effects related to the exposure. He should simply change his clothes and return to work.
   - **B.** You should assist the victim with removing his contaminated pants only, and direct him to the nearest safety shower. Once decontamination is complete, he is eligible to return to work.
   - **C.** The victim should remove all of his own clothing, be accompanied to the nearest safety shower, decontaminated for 15 minutes, and transported to the hospital for medical evaluation. You should keep a safe distance from the victim and avoid touching him. As long as he is alert and able to follow commands, he is still able to help himself.
   - **D.** This chemical is extremely toxic. You and your crew should withdraw from the laboratory and set up a controlled area outside of the building for decontamination. You will need to research the chemical fully, don the appropriate PPE, and then reenter the laboratory later to address the medical needs of the victim.
2. The ambient temperature in the laboratory is 77°F (25°C). The flash point of acetonitrile is 36°F (2°C). Which of the following choices best describes the threat of a flash fire?
   - **A.** The flash point of acetonitrile is well below the temperature of the room. If the vapors reach an uncontrolled ignition source, a flash fire could occur.
   - **B.** The flash point of acetonitrile is so low that it cannot ignite under these conditions
   - **C.** In this scenario, acetonitrile would not give off any flammable vapors.
   - **D.** Eight liters of acetonitrile would create a small puddle and, therefore, would not create much flammable vapor.
3. The vapor density of acetonitrile is 1.4. Based on this value, you can expect that the vapors will be _____ than air.
   - **A.** lighter
   - **B.** darker
   - **C.** more reactive
   - **D.** heavier
4. The MSDS shows the flammable range for acetonitrile to be 4.4 percent to 16 percent. Which of the following definitions for flammable range is most accurate?
   - **A.** An expression of a fuel/air mixture, defined by upper and lower flammable limits, that reflects an amount of flammable vapor mixed with a given volume of air.
   - **B.** A description of the volume increase that occurs when a liquid material changes to a gas.
   - **C.** The minimum temperature at which a fuel, when heated, will ignite in air and continue to burn.
   - **D.** The ability of a chemical to undergo a change in its chemical make-up, usually with the release of some form of energy.

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CHAPTER

# 3

## NFPA 472 Standard

Competencies for Awareness Level Personnel

**4.1.2 Goal.**

**4.1.2.1** The goal of the competencies at the awareness level shall be to provide personnel already on the scene of a hazardous materials/WMD incident with the knowledge and skills to perform the tasks in 4.1.2.2 safely and effectively. [p. 50–75]

**4.1.2.2** When already on the scene of a hazardous materials/WMD incident, the awareness level personnel shall be able to perform the following tasks:

(1) Analyze the incident to determine both the hazardous material/WMD present and the basic hazard and response information for each hazardous material/WMD agent by completing the following tasks:

(a) Detect the presence of hazardous materials/WMD. [p. 50–75]

(b) Survey a hazardous materials/WMD incident from a safe location to identify the name, UN/NA identification number, type of placard, or other distinctive marking applied for the hazardous materials/WMD involved. [p. 50–75]

(c) Collect hazard information from the current edition of the DOT *Emergency Response Guidebook*. [p. 64–66]

(2) Implement actions consistent with the emergency response plan, the standard operating procedures, and the current edition of the DOT *Emergency Response Guidebook* by completing the following tasks:

(a) Initiate protective actions. [p. 64–72]

(b) Initiate the notification process. [p. 64–72]

**4.2 Competencies—Analyzing the Incident.**

**4.2.1 Detecting the Presence of Hazardous Materials/WMD.** Given examples of various situations, awareness level personnel shall identify those situations where hazardous materials/WMD are present and shall meet the following requirements:

(1) Identify the definitions of both *hazardous material* (or *dangerous goods*, in Canada) and *WMD*. [p. 50–51]

(2) Identify the UN/DOT hazard classes and divisions of hazardous materials/WMD and identify common examples of materials in each hazard class or division. [p. 66]

(3) Identify the primary hazards associated with each UN/DOT hazard class and division. [p. 66]

(4) Identify the difference between hazardous materials/WMD incidents and other emergencies. [p. 50–51]

(5) Identify typical occupancies and locations in the community where hazardous materials/WMD are manufactured, transported, stored, used, or disposed of. [p. 50]

(6) Identify typical container shapes that can indicate the presence of hazardous materials/WMD. [p. 50–56]

(7) Identify facility and transportation markings and colors that indicate hazardous materials/WMD, including the following:

(a) Transportation markings, including UN/NA identification number marks, marine pollutant mark, elevated temperature (HOT) mark, commodity marking, and inhalation hazard mark [p. 59–64]

(b) NFPA 704, *Standard System for the Identification of the Hazards of Materials for Emergency Response*, markings [p. 61–63]

(c) Military hazardous materials/WMD markings [p. 63–64]

(d) Special hazard communication markings for each hazard class [p. 63]

(e) Pipeline markings [p. 59]

(f) Container markings [p. 59–64]

(8) Given an NFPA 704 marking, describe the significance of the colors, numbers, and special symbols. [p. 61–63]

(9) Identify U.S. and Canadian placards and labels that indicate hazardous materials/WMD. [p. 59–61]

(10) Identify the following basic information on material safety data sheets (MSDS) and shipping papers for hazardous materials:

(a) Identify where to find MSDS. [p. 67]

(b) Identify major sections of an MSDS. [p. 67]

(c) Identify the entries on shipping papers that indicate the presence of hazardous materials. [p. 66–70]

(d) Match the name of the shipping papers found in transportation (air, highway, rail, and water) with the mode of transportation. [p. 67–70]

(e) Identify the person responsible for having the shipping papers in each mode of transportation. [p. 67–70]

(f) Identify where the shipping papers are found in each mode of transportation. [p. 67–70]

(g) Identify where the papers can be found in an emergency in each mode of transportation. [p. 67–70]

(11) Identify examples of clues (other than occupancy/location, container shape, markings/color, placards/labels, MSDS, and shipping papers) the sight, sound, and odor of which indicate hazardous materials/WMD. [p. 50–51]

(12) Describe the limitations of using the senses in determining the presence or absence of hazardous materials/WMD. [p. 51]

(13) Identify at least four types of locations that could be targets for criminal or terrorist activity using hazardous materials/WMD. [p. 72]

(14) Describe the difference between a chemical and a biological incident. [p. 73]

(15) Identify at least four indicators of possible criminal or terrorist activity involving chemical agents. [p. 72–73]

(16) Identify at least four indicators of possible criminal or terrorist activity involving biological agents. [p. 73]

(17) Identify at least four indicators of possible criminal or terrorist activity involving radiological agents. [p. 73–74]

(18) Identify at least four indicators of possible criminal or terrorist activity involving illicit laboratories (clandestine laboratories, weapons lab, ricin lab). [p. 75]

(19) Identify at least four indicators of possible criminal or terrorist activity involving explosives. [p. 75]

(20) Identify at least four indicators of secondary devices. [p. 75]

**4.2.2 Surveying Hazardous Materials/WMD Incidents.** Given examples of hazardous materials/WMD incidents, awareness level personnel shall, from a safe location, identify the hazardous material(s)/WMD involved in each situation by name, UN/NA identification number, or type placard applied and shall meet the following requirements:

(1) Identify difficulties encountered in determining the specific names of hazardous materials/WMD at facilities and in transportation. [p. 51]

(2) Identify sources for obtaining the names of, UN/NA identification numbers for, or types of placard associated with hazardous materials/WMD in transportation. [p. 59–72]

(3) Identify sources for obtaining the names of hazardous materials/WMD at a facility. [p. 59–72]

**4.2.3 Collecting Hazard Information.** Given the identity of various hazardous materials/WMD (name, UN/NA identification number, or type placard), awareness level personnel shall identify the fire, explosion, and health hazard information for each material by using the current edition of the DOT *Emergency Response Guidebook* and shall meet the following requirements:

(1) Identify the three methods for determining the guidebook page for a hazardous material/WMD. [p. 64–65]

(2) Identify the two general types of hazards found on each guidebook page. [p. 64–65]

**4.4.1 Initiating Protective Actions.** Given examples of hazardous materials/WMD incidents, the emergency response plan, the standard operating procedures, and the current edition of the DOT *Emergency Response Guidebook*, awareness level personnel shall be able to identify the actions to be taken to protect themselves and others and to control access to the scene and shall meet the following requirements:

(1) Identify the location of both the emergency response plan and/or standard operating procedures.

(2) Identify the role of the awareness level personnel during hazardous materials/WMD incidents.

(3) Identify the following basic precautions to be taken to protect themselves and others in hazardous materials/WMD incidents:

(a) Identify the precautions necessary when providing emergency medical care to victims of hazardous materials/WMD incidents.

(b) Identify typical ignition sources found at the scene of hazardous materials/WMD incidents.

(c) Identify the ways hazardous materials/WMD are harmful to people, the environment, and property.

(d) Identify the general routes of entry for human exposure to hazardous materials/WMD.

(4) Given examples of hazardous materials/WMD and the identity of each hazardous material/WMD (name, UN/NA identification number, or type placard), identify the following response information:

(a) Emergency action (fire, spill, or leak and first aid) [p. 64–65]

(b) Personal protective equipment necessary [p. 64–65]

(c) Initial isolation and protective action distances [p. 64–65]

(5) Given the name of a hazardous material, identify the recommended personal protective equipment from the following list:

(a) Street clothing and work uniforms

(b) Structural fire-fighting protective clothing

(c) Positive pressure self-contained breathing apparatus

(d) Chemical-protective clothing and equipment

(6) Identify the definitions for each of the following protective actions:

(a) Isolation of the hazard area and denial of entry

(b) Evacuation

(c) Sheltering in-place

(7) Identify the size and shape of recommended initial isolation and protective action zones.

(8) Describe the difference between small and large spills as found in the Table of Initial Isolation and Protective Action Distances in the DOT *Emergency Response Guidebook*.

(9) Identify the circumstances under which the following distances are used at a hazardous materials/WMD incidents:

(a) Table of Initial Isolation and Protective Action Distances

(b) Isolation distances in the numbered guides

(10) Describe the difference between the isolation distances on the orange-bordered guidebook pages and the protective action distances on the green-bordered *ERG* (*Emergency Response Guidebook*) pages.

(11) Identify the techniques used to isolate the hazard area and deny entry to unauthorized persons at hazardous materials/WMD incidents.

(12) Identify at least four specific actions necessary when an incident is suspected to involve criminal or terrorist activity.

### Core Competencies for Operations Level Responders

**5.2 Core Competencies—Analyzing the Incident.**

**5.2.1 Surveying Hazardous Materials/WMD Incidents.** Given scenarios involving hazardous materials/WMD incidents, the operations level responder shall survey the incident to identify the containers and materials involved, determine whether hazardous materials/WMD have been released, and evaluate the surrounding conditions and shall meet the requirements of 5.2.1.1 through 5.2.1.6. [p. 50–75]

**5.2.1.1** Given three examples each of liquid, gas, and solid hazardous material or WMD, including various hazard classes, operations level personnel shall identify the general shapes of containers in which the hazardous materials/WMD are typically found. [p. 51–56]

**5.2.1.1.1** Given examples of the following tank cars, the operations level responder shall identify each tank car by type, as follows:

(1) Cryogenic liquid tank cars [p. 57–58]

(2) Nonpressure tank cars (general service or low pressure cars) [p. 58]

(3) Pressure tank cars [p. 58–59]

**5.2.1.1.2** Given examples of the following intermodal tanks, the operations level responder shall identify each intermodal tank by type, as follows:

(1) Nonpressure intermodal tanks [p. 53–54]

(2) Pressure intermodal tanks [p. 53–54]

(3) Specialized intermodal tanks, including the following:

(a) Cryogenic intermodal tanks [p. 53–56]

(b) Tube modules [p. 53–54]

**5.2.1.1.3** Given examples of the following cargo tanks, the operations level responder shall identify each cargo tank by type, as follows:

(1) Compressed gas tube trailers [p. 58]

(2) Corrosive liquid tanks [p. 57]

(3) Cryogenic liquid tanks [p. 53–56]

(4) Dry bulk cargo tanks [p. 58]

(5) High pressure tanks [p. 57]

(6) Low pressure chemical tanks [p. 57–58]

(7) Nonpressure liquid tanks [p. 56]

**5.2.1.1.4** Given examples of the following storage tanks, the operations level responder shall identify each tank by type, as follows:

(1) Cryogenic liquid tank [p. 55–56]

(2) Nonpressure tank [p. 53]

(3) Pressure tank [p. 53]

**5.2.1.1.5** Given examples of the following nonbulk packaging, the operations level responder shall identify each package by type, as follows:

(1) Bags [p. 55]

(2) Carboys [p. 55]

(3) Cylinders [p. 55]

(4) Drums [p. 54]

(5) Dewar flask (cryogenic liquids)

**5.2.1.1.6** Given examples of the following radioactive material packages, the operations level responder shall identify the characteristics of each container or package by type, as follows:

(1) Excepted [p. 75]

(2) Industrial [p. 75]

(3) Type A [p. 74]

(4) Type B [p. 74]

(5) Type C [p. 75]

**5.2.1.2** Given examples of containers, the operations level responder shall identify the markings that differentiate one container from another. [p. 51–56]

**5.2.1.2.1** Given examples of the following marked transport vehicles and their corresponding shipping papers, the operations level responder shall identify the following vehicle or tank identification marking:

(1) Highway transport vehicles, including cargo tanks [p. 56–58]

(2) Intermodal equipment, including tank containers [p. 53–54]

(3) Rail transport vehicles, including tank cars [p. 58–59]

**5.2.1.2.2** Given examples of facility containers, the operations level responder shall identify the markings indicating container size, product contained, and/or site identification numbers. [p. 51–56]

**5.2.1.3** Given examples of hazardous materials incidents, the operations level responder shall identify the name(s) of the hazardous material(s) in 5.2.1.3.1 through 5.2.1.3.3. [p. 55–74]

**5.2.1.3.1** The operations level responder shall identify the following information on a pipeline marker:

(1) Emergency telephone number [p. 59]

(2) Owner [p. 59]

(3) Product [p. 59]

**5.2.1.3.2** Given a pesticide label, the operations level responder shall identify each of the following pieces of information, then match the piece of information to its significance in surveying hazardous materials incidents:

(1) Active ingredient [p. 55]

(2) Hazard statement [p. 55]

(3) Name of pesticide [p. 55]

(4) Pest control product (PCP) number (in Canada) [p. 55]

(5) Precautionary statement [p. 55]

(6) Signal word [p. 55]

**5.2.1.3.3** Given a label for a radioactive material, the operations level responder shall identify the type or category of label, contents, activity, transport index, and criticality safety index as applicable. [p. 72–74]

**5.2.1.4** The operations level responder shall identify and list the surrounding conditions that should be noted when a hazardous materials/WMD incident is surveyed. [p. 50–51]

**5.2.1.5** The operations level responder shall give examples of ways to verify information obtained from the survey of a hazardous materials/WMD incident. [p. 59–72]

**5.2.1.6** The operations level responder shall identify at least three additional hazards that could be associated with an incident involving terrorist or criminal activities. [p. 72–75]

**5.2.2 Collecting Hazard and Response Information.** Given scenarios involving known hazardous materials/WMD, the operations level responder shall collect hazard and response information using MSDS, CHEMTREC/CANUTEC/SETIQ, governmental authorities, and shippers and manufacturers and shall meet the following requirements:

(1) Match the definitions associated with the UN/DOT hazard classes and divisions of hazardous materials/WMD, including refrigerated liquefied gases and cryogenic liquids, with the class or division. [p. 66]

(2) Identify two ways to obtain an MSDS in an emergency. [p. 67–68]

(3) Using an MSDS for a specified material, identify the following hazard and response information:

(a) Physical and chemical characteristics [p. 67]

(b) Physical hazards of the material [p. 67]

(c) Health hazards of the material [p. 67]

(d) Signs and symptoms of exposure [p. 67]

(e) Routes of entry [p. 67]

(f) Permissible exposure limits [p. 67]

(g) Responsible party contact [p. 67]

(h) Precautions for safe handling (including hygiene practices, protective measures, and procedures for cleanup of spills and leaks) [p. 67]

(i) Applicable control measures, including personal protective equipment [p. 67]

(j) Emergency and first-aid procedures [p. 67]

(4) Identify the following:

(a) Type of assistance provided by CHEMTREC/CANUTEC/SETIQ and governmental authorities [p. 70–72]

(b) Procedure for contacting CHEMTREC/CANUTEC/SETIQ and governmental authorities [p. 70–72]

(c) Information to be furnished to CHEMTREC/CANUTEC/SETIQ and governmental authorities [p. 70–72]

(5) Identify two methods of contacting the manufacturer or shipper to obtain hazard and response information. [p. 67–72]

(6) Identify the type of assistance provided by governmental authorities with respect to criminal or terrorist activities involving the release or potential release of hazardous materials/WMD. [p. 72]

(7) Identify the procedure for contacting local, state, and federal authorities as specified in the emergency response plan and/or standard operating procedures. [p. 72]

(8) Describe the properties and characteristics of the following:

(a) Alpha radiation

(b) Beta radiation

(c) Gamma radiation

(d) Neutron radiation

**5.2.3 Predicting the Likely Behavior of a Material and Its Container.** Given scenarios involving hazardous materials/WMD incidents, each with a single hazardous material/WMD, the operations level responder shall predict the likely behavior of the material or agent and its container and shall meet the following requirements:

(1) Interpret the hazard and response information obtained from the current edition of the *Emergency Response Guidebook*, MSDS, CHEMTREC/CANUTEC/SETIQ, governmental authorities, and shipper and manufacturer contacts, as follows:

(a) Match the following chemical and physical properties with their significance and impact on the behavior of the container and its contents:

i. Boiling point

ii. Chemical reactivity

iii. Corrosivity (pH)

iv. Flammable (explosive) range [lower explosive limit (LEL) and upper explosive limit (UEL)

v. Flash point

vi. Ignition (autoignition) temperature

vii. Particle size

viii. Persistence

ix. Physical state (solid, liquid, gas)

x. Radiation (ionizing and non-ionizing)

xi. Specific gravity

xii. Toxic products of combustion

xiii. Vapor density

xiv. Vapor pressure

xv. Water solubility

(b) Identify the differences between the following terms:
   i. *Contamination* and *secondary contamination*
   ii. *Exposure* and *contamination*
   iii. *Exposure* and *hazard*
   iv. *Infectious* and *contagious*
   v. *Acute effects* and *chronic effects*
   vi. *Acute exposures* and *chronic exposures*

(2) Identify three types of stress that can cause a container system to release its contents.
(3) Identify five ways in which containers can breach.
(4) Identify four ways in which containers can release their contents.
(5) Identify at least four dispersion patterns that can be created upon release of a hazardous material.
(6) Identify the time frames for estimating the duration that hazardous materials/WMD will present an exposure risk.
(7) Identify the health and physical hazards that could cause harm.
(8) Identify the health hazards associated with the following terms:
   (a) Alpha, beta, gamma, and neutron radiation
   (b) Asphyxiant
   (c) Carcinogen
   (d) Convulsant
   (e) Corrosive
   (f) Highly toxic
   (g) Irritant
   (h) Sensitizer, allergen
   (i) Target organ effects
   (j) Toxic
(9) Given the following, identify the corresponding UN/DOT hazard class and division:
   (a) Blood agents [p. 66]
   (b) Biological agents and biological toxins [p. 66]
   (c) Choking agents [p. 66]
   (d) Irritants (riot control agents) [p. 66]
   (e) Nerve agents [p. 66]
   (f) Radiological materials [p. 66]
   (g) Vesicants (blister agents) [p. 66]

## Knowledge Objectives

After studying this chapter, you will be able to:

- Describe occupancies that may contain hazardous materials.
- Describe how your senses can be used to detect the presence of hazardous materials.
- Describe specific containers and container shapes that might indicate hazardous materials.
- Describe shipping and storage tanks that could hold hazardous materials.
- Describe apparatuses that can transport hazardous materials.
- Describe how to identify the product, owner, and emergency telephone number on a pipeline marker.
- Describe how to identify a placard, label, and marking.
- Describe the NFPA 704 hazard identification system.
- Describe how to use the *Emergency Response Guidebook* (*ERG*).
- Describe how to use the *Fire Fighter's Handbook of Hazardous Materials*.
- Describe material safety data sheets (MSDS) and shipping papers.
- Describe CHEMTREC and the National Response Center.
- Describe how to identify criminal or terrorist activity involving chemical, biological, or radiological agents.
- Describe how to identify an illicit laboratory, explosive and secondary devices.

## Skills Objectives

After studying this chapter, you will be able to:

- Use the *Emergency Response Guidebook*.

## You Are the Responder

During an odor investigation in a light-industrial area of your district, you are directed to a small metal building behind a 50′ × 150′ tilt-up concrete structure. The metal building has a large roll-up door facing you, adjacent to several standard passage-type doors. Three steel drums with red diamond-shaped labels are located next to the building, resting on an asphalt surface. The maintenance supervisor says that he noticed an unusual odor when he walked by the drums and indicates that a large area around the drums is wet.

1. Which type of material might be stored in a steel drum?
2. What do the labels on the drums signify?
3. How would you go about obtaining more in-depth information on the potential contents of the drums?

## Introduction

Scene size-up is important in any emergency situation, but especially in hazardous materials incidents. The ability to "read" the scene is a critical skill, and responders must be able to interpret the available clues so that they can operate as safely as possible. It is not enough to simply scan the emergency scene—you must train yourself to stop for a moment and truly understand what you are seeing. Remember to think before you act: It could save your life! Looking at something is nothing more than pointing your eyes in the right direction; seeing, by contrast, is taking in the visual clues and piecing them together to form a conclusion.

It may be possible to detect the presence of a hazardous materials emergency based on information from the dispatcher or persons on the scene, or based on your own knowledge of the response area. Departmental standard operating procedures (SOPs) and your level of training, along with your information-gathering efforts at the scene, should guide your initial actions.

### Responder Safety Tips

A weapon of mass destruction (WMD), as defined in NFPA 472, *Standard for Competence of Responders to Hazardous Materials/Weapons of Mass Destruction Incidents*, includes (1) any destructive device, such as any explosive, incendiary, or poison gas, bomb, grenade, rocket having a propellant charge of more than 4 ounces, missile having an explosive or incendiary charge of more than one-quarter ounce (7 grams), mine, or device similar to the above; (2) any weapon involving toxic or poisonous chemicals; (3) any weapon involving a disease organism; or (4) any weapon that is designed to release radiation or radioactivity at a level dangerous to human life.

More than 4 billion tons of hazardous materials are shipped annually in the United States by land, sea, air, and rail. While it is not possible to know each and every chemical by name or by hazard class, it is possible to identify many of the more common commodities by understanding the available identification systems and using other methods to identify the presence of a hazardous material. This chapter provides you with guidance on interpreting visual clues such as containers, placards, labels, and shipping information, all of which may signal the possible presence of a hazardous materials incident.

## Recognizing a Hazardous Materials/ Weapons of Mass Destruction Incident

A hazardous material, as defined by the U.S. Department of Transportation (DOT), is any substance or material that is capable of posing an unreasonable risk to human health, safety, or the environment when transported in commerce, used incorrectly, or not properly contained or stored. Recognizing a hazardous materials/weapons of mass destruction (WMD) event, determining the identity of the material(s), and understanding the hazards involved often require some detective work. You must train yourself to take the time to look at the whole scene so that you can identify the critical visual indicators and fit them into what is known about the problem. Some of the key differences between hazardous materials/WMD emergencies and other types of emergencies include:

- A hazardous materials/WMD emergency moves more slowly than other emergencies and usually does not require responders to rush headlong into the problem.
- Responders must understand that actions taken at hazardous materials/WMD incidents are largely dictated by the chemicals or hazards involved.

- Personnel operating at the scene of a hazardous materials/WMD incident must be conscious of the law enforcement aspect of the incident.

Initially, it is important to approach the scene from a safe location and direction. The traditional rules of staying uphill and upwind are a good place to start. Additionally, it may be wise to use binoculars and view the scene from a safe distance. Be sure to question anyone involved in the incident—a wealth of information may be available to you if you simply ask the right person. Take enough time to assess the scene and interpret other clues such as dead animals near the release, discolored pavement, dead grass, visible vapors or puddles, or labels that may help identify the presence of a hazardous material. Once you have a basic idea of what happened or determine that danger may be present, you can begin to formulate a plan for addressing the incident.

### Occupancy and Location

A wide variety of chemicals are stored in warehouses, hospitals, laboratories, industrial occupancies, residential garages, bowling alleys, home improvement centers, garden supply stores, restaurants, and scores of other facilities or businesses in your response area. So many different chemicals exist in so many different locations that you could encounter almost anything during any type of emergency situation.

The location and type of occupancy are two good indicators of the possible presence of a hazardous material. Chapter 1 discussed the importance of preplanning a response to occupancies that use hazardous materials. Identifying the kinds and quantities of hazardous materials used and stored by local facilities should be an integral part of any comprehensive community response plan. Once a chemical emergency has occurred at a particular occupancy, however, there are some key personnel that responders should locate. Generally speaking, most fixed facilities that use and/or store a significant amount of chemicals will have an Environmental Health and Safety (EH&S) department. In many cases, EH&S departments will employ certified industrial hygienists, chemists and chemical engineers, and/or certified safety professionals to ensure safe work practices at the site. These industry experts may be a valuable source of information for understanding the chemical inventory of the facility, the ventilation systems, high-hazard chemical storage areas, and specialized areas such as clean rooms. Additionally, representatives of the EH&S department have the ability to connect the responders with site security, maintenance workers, and other important employees at the facility.

### Senses

Another way to detect the presence of hazardous materials is to use your senses, although this technique must be employed carefully to avoid becoming contaminated or exposed. The senses that can be safely used are those of sight and sound. Initially, the farther you are from the incident when you notice a problem, the safer you will be. Using any of your senses that bring you in close proximity to the chemical should be done with caution or avoided. When it comes to hazardous materials incidents, "leading with your nose" is not a good tactic—but using binoculars from a distance is.

Clues that are seen or heard may provide warning information from a distance, enabling you to take precautionary steps. Vapor clouds at the scene, for example, are a signal to move yourself and others away to a place of safety; the sound of an alarm from a toxic gas sensor in a chemical storage room or laboratory may also serve as a warning to retreat. Some highly vaporous and odorous chemicals—chlorine and ammonia, for example—may be detected by smell a long way from the actual point of release. These and other clues may alert the operations level responder to the presence of a hazardous atmosphere.

## Containers

In basic terms, a container is any vessel or receptacle that holds a material. Often the container type, size, and material of construction provide important clues about the nature of the substance inside. Nevertheless, responders should not rely solely on the type of container when making a determination about hazardous materials.

Red phosphorus from a drug laboratory, for example, might be found in an unmarked plastic container. In this case, there may be no legitimate markings to alert a responder to the possible contents. Gasoline or waste solvents may be stored in 55-gallon steel drums with two capped openings (2" and ¾") on the top. Sulfuric acid, at 97 percent concentration, could be found in a polyethylene drum that might be colored black, red, white, or blue. In most cases, there is no correlation between the color of the drum and the possible contents. The same sulfuric acid might also be found in a 1-gallon amber glass container. Hydrofluoric acid, by contrast, is incompatible with silica (glass) and would be stored in a plastic container. Steel or polyethylene drums, bags, high-pressure gas cylinders, railroad tank cars, plastic buckets, above-ground and underground storage tanks, cargo tanks, and pipelines are all representative examples of how hazardous materials are used, stored, and shipped Figure 3-1 ▸.

Some very recognizable chemical containers, such as 55-gallon drums and compressed gas cylinders, can be found in almost every type of manufacturing facility. Materials stored in a cardboard drum are usually in solid form. Stainless steel containers hold particularly dangerous chemicals, and cold liquids are kept in Thermos-like Dewar containers designed to maintain the appropriate temperature Figure 3-2 ▸.

One way to distinguish containers is to divide them into two categories based on their capacity: bulk and nonbulk storage containers.

**Responder Tips**

When you consider locations for possible hazardous materials incidents, do not limit your thinking. Explore your response district—you may be surprised at how many different kinds of containers you find.

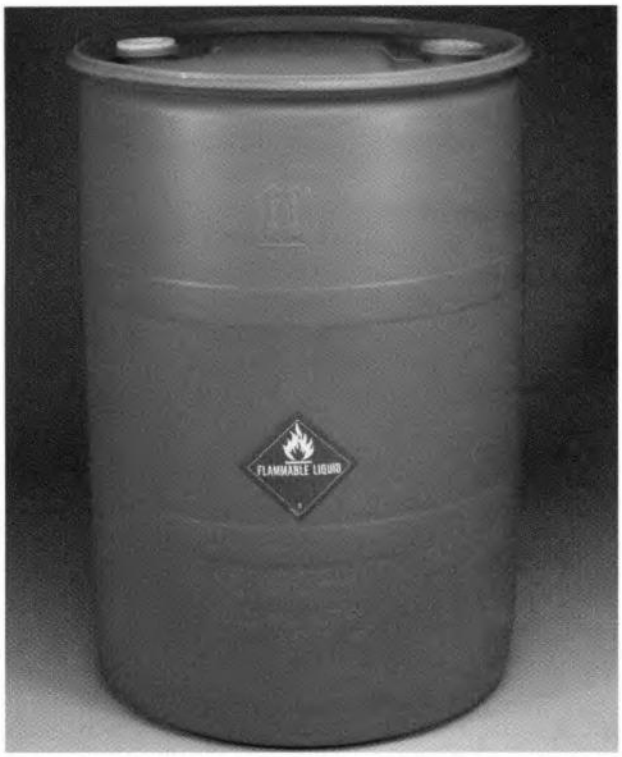



Figure 3-1 Drums may be constructed of many different types of materials, including cardboard, polyethylene, or stainless steel. The drum shown here is made of polyethylene.

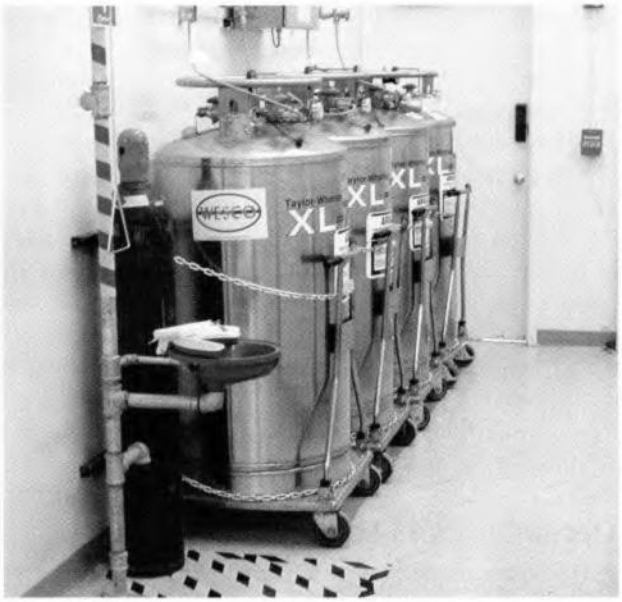



Figure 3-2 A series of Dewar containers stored adjacent to a compressed gas cylinder.

## Container Volume

Bulk storage containers, or large-volume containers, are defined by their internal capacity based on the following measures:

- Liquids: greater than 119 gallons; or
- Bulk packaging with a net mass greater than 882 pounds

Bulk storage containers include fixed tanks, highway cargo tanks, rail tank cars, totes, and intermodal tanks.

In general, bulk storage containers are found in occupancies that rely on and need to store large quantities of a particular chemical. Most manufacturing facilities have at least one type of bulk storage container Table 3-1. Often these bulk storage containers are surrounded by a supplementary containment system to help control an accidental release. Secondary containment is an engineered method to control spilled or released product if the main containment vessel fails. A 5000-gallon vertical storage tank, for example, may be surrounded by a series of short walls that form a catch basin around the tank.

Secondary containment basins typically can hold the entire volume of the tank along with a percentage of the water flowed from hose lines or sprinkler systems in the event of fire. Many storage vessels, including 55-gallon drums, may have secondary containment systems. If facilities that use bulk storage containers in your response area have secondary containment systems, it will be easier to handle leaks when they occur.

**Table 3-1 Common Bulk Storage Vessels, Locations, and Contents**

| Tank Shape | Common Locations | Hazardous Materials Commonly Stored |
|---|---|---|
| Underground tanks | Residential, commercial | Fuel oil and combustible liquids |
| Covered floating roof tanks | Bulk terminals and storage | Highly volatile flammable liquids |
| Cone roof tanks | Bulk terminal and storage | Combustible liquids |
| Open floating roof tanks | Bulk terminal and storage | Flammable and combustible liquids |
| Dome roof tanks | Bulk terminal and storage | Combustible liquids |
| High-pressure horizontal tanks | Industrial storage and terminal | Flammable gases, chlorine, ammonia |
| High-pressure spherical tanks | Industrial storage and terminal | Liquid propane gas, liquid nitrogen gas |
| Cryogenic liquid storage tanks | Industrial and hospital storage | Oxygen, liquid nitrogen gas |

Large-volume horizontal tanks are also common at fixed facilities. When stored above ground, these tanks are referred to as above-ground storage tanks (ASTs); if they are placed underground, they are known as underground storage tanks (USTs). These tanks can hold a few hundred gallons to several million gallons of product and are usually made of aluminum, steel, or plastic. USTs and ASTs can be pressurized or nonpressurized. Nonpressurized horizontal tanks are usually made of steel or aluminum. Because it is difficult to relieve the internal pressure in these tanks, they pose a danger when they are exposed to fire. Typically, these containers hold flammable or combustible materials such as gasoline, oil, or diesel fuel.

Pressurized horizontal tanks have rounded ends and large vents or pressure-relief stacks. The most common above-ground pressurized tanks contain liquid propane and liquid ammonia; such containers can hold a few hundred gallons to several thousand gallons of product. These tanks usually have a small vapor space—called the headspace—above the liquid. In most cases, 10 to 15 percent of the total container capacity is vapor.

Another commonly encountered bulk storage vessel is the tote, also referred to as an intermediate bulk container (IBC) Figure 3-3. Totes have capacities ranging from 119 gallons to 703 gallons. These portable plastic tanks are surrounded by a stainless steel web that adds both structural stability and protection to the container. They can hold hundreds of gallons of product and may contain any type of chemical, including flammable liquids, corrosives, food-grade liquids, or oxidizers.

Shipping and storing totes can be hazardous. These containers often are stacked atop one another and moved with a forklift, such that a mishap with the loading or moving process can compromise the tote. Because totes have no secondary containment system, any leak has the potential to create a large puddle. Additionally, the steel webbing around the tote makes it difficult to access and patch leaks.

Intermodal tanks are both shipping and storage vessels. They hold between 5000 gallons and 6000 gallons of product and can be either pressurized or nonpressurized. Intermodal (IM or IMO) tanks can also be used to ship and store gaseous substances that have been chilled until they liquefy (cryogenic liquids), such as liquid nitrogen and liquid argon. In most cases, an IM tank is shipped to a facility, where it is stored and used, and then returned to the shipper for refilling. Intermodal tanks can be shipped by all methods of transportation—air, sea, or land.

A box-like steel framework, constructed to facilitate efficient stacking and shipping, typically surrounds an IM tank. Several types of IM tanks are available:

- IM-101 portable tanks (IMO type 1 internationally) have a 6300-gallon capacity, with internal working pressures between 25.4 pounds per square inch (psi) and 100 psi. These containers typically carry mild corrosives, food-grade products, and flammable liquids Figure 3-4A.

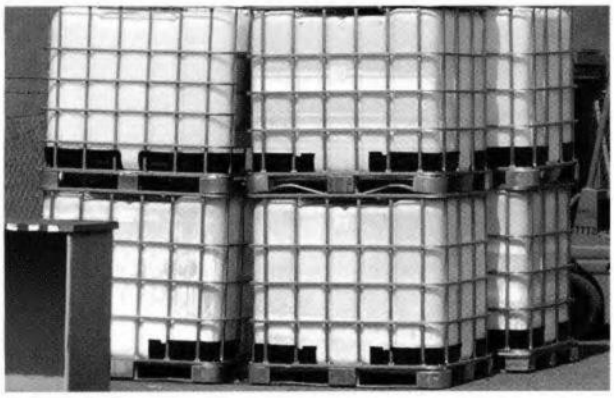


Figure 3-3 A tote is a commonly encountered bulk storage vessel.

A.

B.

C.

Figure 3-4 **A.** IM-101 portable tanks (IMO type 1 internationally). **B.** IM-102 portable tanks (IMO type 2 internationally). **C.** Pressure intermodal tanks (IMO type 5 internationally).

- IM-102 portable tanks (IMO type 2 internationally) have a 6300-gallon capacity, with internal working pressures between 14.7 psi and 25.4 psi. They primarily carry nonhazardous materials but may also contain flammable liquids and corrosives Figure 3-4B.
- Pressure intermodal tanks (IMO type 5 internationally) are high-pressure vessels with internal pressures in the range of 100–600 psi. These intermodal containers commonly hold liquefied compressed gases such as propane and butane Figure 3-4C.
- Cryogenic intermodal tanks (IMO type 7 internationally) are low-pressure containers in transport but can be pressurized to 600 psi. This kind of container commonly carries cryogenic materials that have temperatures less than –150°F, such as liquefied oxygen, nitrogen, or helium.
- Tube modules consist of several high-pressure tubes attached to a frame. The tubes are individually specified and have working pressures that range as high as 5000 psi. The products commonly carried include hydrogen and oxygen.

## Nonbulk Storage Vessels

Essentially, nonbulk storage vessels are all types of containers other than bulk containers. Nonbulk storage vessels can hold a few ounces to 119 gallons of product and include vessels such as drums, bags, compressed gas cylinders, cryogenic containers, and more. Nonbulk storage vessels hold commonly used commercial and industrial chemicals such as solvents, industrial cleaners, and compounds. This section describes the most commonly encountered types of nonbulk storage vessels.

### Drums

Drums are easily recognizable, barrel-like containers. They are used to store a wide variety of substances, including food-grade materials, corrosives, flammable liquids, and grease. Drums may be constructed of low-carbon steel, polyethylene, cardboard, stainless steel, nickel, or other materials. Generally, the nature of the chemical dictates the construction of the storage drum. Steel utility drums, for example, hold flammable liquids, cleaning fluids, oil, and other noncorrosive chemicals. Polyethylene drums are used for corrosives such as acids, bases, oxidizers, and other materials that cannot be stored in steel containers. Cardboard drums hold solid materials such as soap flakes, sodium hydroxide pellets, and food-grade materials. Stainless steel or other heavy-duty drums generally hold materials too aggressive (i.e., too reactive) for either plain steel or polyethylene.

Closed-head drums have a permanently attached lid with one or more small openings called bungs. Typically, these openings are threaded holes sealed by caps that can be removed only by using a special tool called a bung wrench Figure 3-5. Closed-head drums usually have one 2" bung and one ¾" bung. The larger bung is used to pump product from the drum; the smaller bung functions as a vent.

An open-head drum has a removable lid fastened to the drum with a ring Figure 3-6. The ring is tightened with a clasp or a threaded nut-and-bolt assembly.

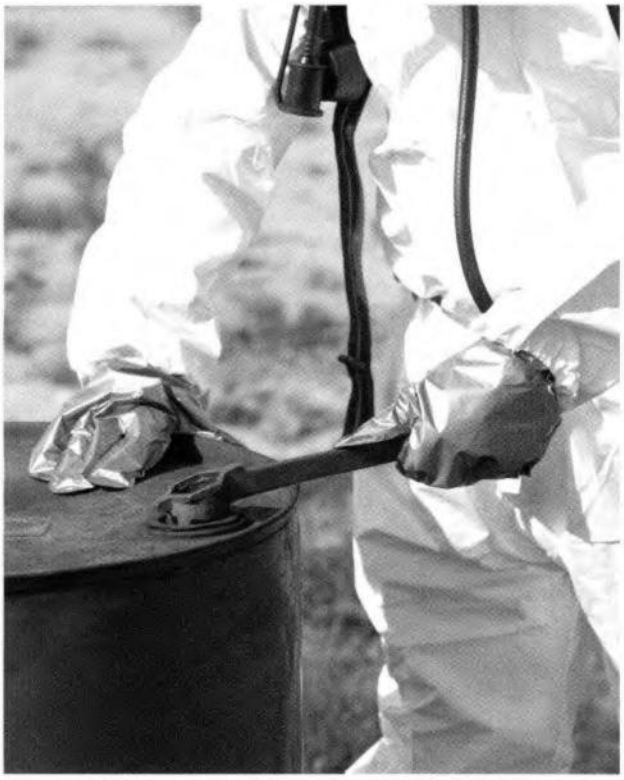


Figure 3-5 A bung wrench is used to operate the openings on the top of a closed-head drum.

Figure 3-6 An open-head drum has a lid that is fastened with a ring that is tightened with a clasp or a nut-and-bolt assembly.

### Bags

Bags are commonly used to store solids and powders such as cement powder, sand, pesticides, soda ash, and slaked lime. Storage bags may be constructed of plastic, paper, or plastic-lined paper. Bags come in different sizes and weights, depending on their contents.

Pesticide bags must be labeled with specific information Figure 3-7. Responders can learn a great deal from the label, including the following details:

- Name of the product
- Active ingredients
- Hazard statement
- The total amount of product in the container
- The manufacturer's name and address
- The Environmental Protection Agency (EPA) registration number, which provides proof that the product was registered with the EPA
- The EPA establishment number, which shows where the product was manufactured
- Signal words to indicate the relative toxicity of the material:
  - Danger—Poison: Highly toxic by all routes of entry
  - Danger: Severe eye damage or skin irritation
  - Warning: Moderately toxic
  - Caution: Minor toxicity and minor eye damage or skin irritation
- Practical first-aid treatment description
- Directions for use
- Agricultural use requirements
- Precautionary statements such as mixing directions or potential environmental hazards
- Storage and disposal information
- Classification statement on who may use the product

In addition, every pesticide label must carry the statement, "Keep out of reach of children." In Canada, the pest control product (PCP) number can also be found on the pesticide label.

### Carboys

Some corrosives and other types of chemicals are transported and stored in vessels called carboys Figure 3-8. A carboy is a glass, plastic, or steel container that holds 5 to 15 gallons of product. Glass carboys are often placed in a protective wood, foam, fiberglass, or steel box to help prevent breakage. For example, nitric acid, sulfuric acid, and other strong acids are often transported and stored in thick glass carboys protected by a wooden or Styrofoam crate to shield the glass container from damage during normal shipping.

### Cylinders

Several types of cylinders are used to hold liquids and gases. Uninsulated compressed gas cylinders are used to store substances such as nitrogen, argon, helium, and oxygen. They come in a range of sizes and have variable internal pressures. An oxygen cylinder used for medical purposes, for example, has a pressure reading of approximately 2000 psi when full. By comparison, the very large compressed gas cylinders found at a fixed facility may have pressure readings of 5000 psi or greater.

The high pressures exerted by these cylinders create a potential for danger. If the cylinder is punctured or the valve assembly fails, the rapid release of compressed gas will turn the cylinder into an unpredictable missile. Also, if the cylinder is heated rapidly, it could explode with tremendous force, spewing product and metal fragments over long distances. Compressed gas cylinders have pressure-relief valves, but those valves may not be sufficient to relieve the pressure created during a fast-growing fire.

A propane cylinder is another type of compressed gas cylinder. Propane cylinders have lower pressures (200–300 psi) and contain a liquefied gas. Liquefied gases such as propane are subject to the phenomenon known as BLEVE (boiling liquid/expanding vapor explosion). BLEVEs occur when pressurized liquefied materials (propane or butane, for example) inside a closed vessel are exposed to a source of high heat.

The low-pressure Dewar container is another commonly encountered cylinder type. Dewars are Thermos-like vessels designed to hold cryogenic liquids (cryogens) such as helium, liquid nitrogen, and liquid argon Figure 3-9.

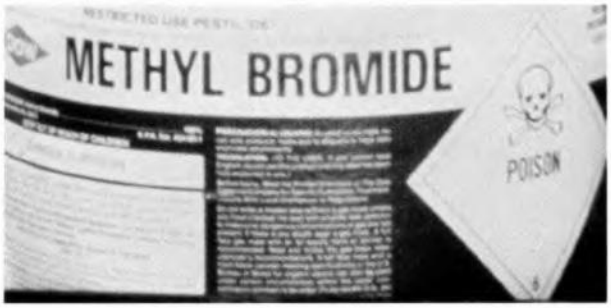



Figure 3-7 A pesticide bag must be labeled with the appropriate information.

Figure 3-8 A carboy is used to transport and store corrosive chemicals.

Figure 3-9 A small cryogenic Dewar container.

Typical cryogens include oxygen, helium, hydrogen, argon, and nitrogen. Under normal atmospheric conditions, each of these substances is a gas. A complex process turns them into liquids that can be stored and used for long periods of time. Nitrogen, for example, becomes a liquid at –320°F (–160°C) and must be kept at that temperature if it is to remain in a liquid state.

Cryogens pose a substantial threat if the Dewar container fails to maintain the low temperature of the cryogenic liquid. Cryogens have large expansion ratios—even larger than the expansion ratio of propane (270:1). Cryogenic helium, for example, has an expansion ratio of approximately 750 to 1. If one volume of liquid helium is warmed to room temperature and vaporized in a totally enclosed container, it can generate a pressure of more than 14,500 psi. To counter this possibility, cryogenic containers usually have two pressure-relief devices: a pressure-relief valve and a frangible (easily broken) metal disk.

**Responder Safety Tips**

Beware of skin exposures to cryogens. Significant injuries, similar to those associated with thermal burns, can occur when skin comes in contact with one of these liquids.

# Transporting Hazardous Materials

Hazardous materials may be transported by air, sea, and land. Although transportation of hazardous materials occurs most often on the roadway, when another method of transport is used, roadway vehicles often transport the shipments from the rail station, airport, or dock to the point where it will be used. For this reason, responders must become familiar with all types of chemical transport vehicles they might encounter during a transportation emergency.

## Roadway Transportation

As mentioned previously, the most common method of hazardous material transport is over land, by roadway transportation vehicles. According to the Code of Federal Regulations, 49 CFR 171.8(2), or local jurisdictional regulations (for example, Transport Canada), a cargo tank is bulk packaging that is permanently attached to or forms a part of a motor vehicle, or is not permanently attached to any motor vehicle, and that, because of its size, construction, or attachment to a motor vehicle, is loaded or unloaded without being removed from the motor vehicle. The U.S. Department of Transportation (DOT) does not view tube trailers (which consist of several individual cylinders banded together and affixed to a trailer) as cargo tanks.

One of the most common and reliable transportation vessels is the MC-306/DOT 406 flammable liquid tanker Figure 3-10. These tanks frequently carry liquid food-grade products, gasoline, or other flammable and combustible liquids. The oval-shaped tank is pulled by a diesel tractor and can carry between 6000 gallons and 10,000 gallons of product. The MC-306/DOT 406 is nonpressurized (its working pressure is between 2.65 psi and 4 psi), usually made of aluminum or stainless steel, and offloaded through valves at the bottom of the tank. These cargo tanks have several safety features, including full rollover protection and remote emergency shut-off valves Figure 3-11.

A vehicle that is similar to the MC-306/406 is the MC-307/DOT 407 chemical hauler. It has a round or horseshoe-shaped tank and is capable of holding 6000 to 7000 gallons of liquid Figure 3-12. The MC-307/DOT 407, which is also a tractor-drawn tank, is used to transport flammable liquids,

Figure 3-10 The MC-306/DOT 406 flammable liquid tanker typically hauls flammable and combustible liquids.

Figure 3-11 The MC-306/DOT 406 cargo tanker has a remote emergency shut-off valve as a safety feature.

Figure 3-13 The MC-312/DOT 412 corrosives tanker is commonly used to carry corrosives such as concentrated sulfuric acid, phosphoric acid, and sodium hydroxide.

mild corrosives, and poisons. This type of cargo tank may be insulated (horseshoe) or uninsulated (round), and have a higher internal working pressure than the MC-306/406—in some cases up to 35 psi. Cargo tanks that transport corrosives may have a rubber lining to prevent corrosion of the tank structure. — not to exceed 40 psi, according to test

The MC-312/DOT 412 corrosives tanker is commonly used to carry corrosives such as concentrated sulfuric acid, phosphoric acid, and sodium hydroxide Figure 3-13. This cargo tank has a smaller diameter than either the MC-306/DOT 406 or the MC-307/DOT 407 and is often identifiable by the presence of several heavy-duty reinforcing rings around the tank. The rings provide structural stability during transportation and in the event of a rollover. The inside of an MC-312/DOT 412 tanker operates at approximately 15 to 25 psi and holds approximately 6000 gallons. These cargo tanks have substantial rollover protection to reduce the potential for damage to the top-mounted valves.

The MC-331 pressure cargo tanker carries materials such as ammonia, propane, Freon, and butane Figure 3-14. The liquid volume inside the tank varies, ranging from the 1000-gallon delivery truck to the full-size 11,000-gallon cargo tank. The MC-331 cargo tank has rounded ends, typical of a pressurized vessel, and is commonly constructed of steel or stainless steel with a single tank compartment. The MC-331 operates at approximately 300 psi, with typical internal working pressures being in the vicinity of 250 psi. These cargo tanks are equipped with spring-loaded relief valves that traditionally operate at 110 percent of the designated maximum working pressure. A significant explosion hazard arises if a MC-331 cargo tank is impinged on by fire, however. Due to the nature of most materials carried in MC-331 tanks, a threat of explosion exists because of the inability of the relief valve to keep up with the rapidly building internal pressure. Responders must use great care when dealing with this type of transportation emergency.

Figure 3-14 The MC-331 pressure cargo tanker carries materials such as ammonia, propane, Freon, and butane.

The MC-338 cryogenic tanker operates much like the Dewar container described earlier and carries many of the same substances Figure 3-15. This low-pressure tanker relies on tank insulation to maintain the low temperatures required for

Figure 3-12 The MC-307/DOT 407 chemical hauler carries flammable liquids, mild corrosives, and poisons.

Figure 3-15 The MC-338 cryogenic tanker maintains the low temperatures required for the cryogens it carries.

the cryogens it carries. A boxlike structure containing the tank control valves is typically attached to the rear of the tanker. Special training is required to operate valves on this and any other tanker. An untrained individual who attempts to operate the valves may disrupt the normal operation of the tank, thereby compromising its ability to keep the liquefied gas cold and creating a potential explosion hazard. Cryogenic tankers have a relief valve near the valve control box. From time to time, small puffs of white vapor will be vented from this valve. Responders should understand that this is a normal occurrence—the valve is working to maintain the proper internal pressure. In most cases, this vapor is not indicative of an emergency situation.

Tube trailers carry compressed gases such as hydrogen, oxygen, helium, and methane Figure 3-16. Essentially, they are high-volume transportation vehicles that are made up of several individual cylinders banded together and affixed to a trailer. The individual cylinders on the tube trailer are much like the smaller compressed gas cylinders discussed earlier in this chapter. These large-volume cylinders operate at working pressures of 3000 to 5000 psi. One trailer may carry several different gases in individual tubes. Typically, a valve control box is found toward the rear of the trailer, and each individual cylinder has its own relief valve. These trailers can frequently be seen at construction sites or at facilities that use large quantities of compressed gases.

Figure 3-16 A tube trailer.

Dry bulk cargo tanks are commonly seen on the road; they carry dry bulk goods such as powders, pellets, fertilizers, or grain Figure 3-17. These tanks are not pressurized, but may use pressure to offload the product. Dry bulk cargo tanks are generally V-shaped with rounded sides that funnel the contents to the bottom-mounted valves.

## Railroad Transportation

Railroads move almost 2 million carloads of freight each year in the United States, with relatively few hazardous materials incidents. Even so, responders should recognize that when rail incidents do occur, they can create unique and significant hazards. Railway cars include passenger cars, freight cars, and tank cars, some of which are capable of carrying more than 30,000 gallons of product. Hazardous materials incidents involving railroad transportation have the potential to be large-scale emergencies.

Operations level responders should recognize three basic types of rail tank cars: nonpressurized, pressurized, and special use. Each has a distinctive profile that can be recognized from a distance. Additionally, rail tank cars are usually labeled on both sides with, among other things, the owner of the car, the car's capacity, and the specification. With dedicated haulers, the chemical name is often clearly visible on both sides of the rail tank car.

Nonpressurized (general-service) rail tank cars typically carry general industrial chemicals and consumer products such as corn syrup, flammable and combustible liquids, and mild corrosives. The new style of the nonpressurized rail tank car has visible valves and piping without a dome cover on top Figure 3-18. Older nonpressurized railcars may have a dome that covers the top-mounted valves and bottom outlet valves. Nonpressurized rail tank cars may hold volumes ranging from 4000 to 40,000 gallons.

Pressurized rail tank cars transport materials such as propane, ammonia, ethylene oxide, and chlorine. These cars have internal working pressures ranging from 100 to 500 psi and are equipped with top-mounted fittings for loading and unloading. These fittings are protected by a sturdy and easily identified dome that sits atop the rail tank car Figure 3-19. Unfortunately, the high volumes carried in these cars can gen-

Figure 3-17 A dry bulk cargo tank carries dry goods such as powders, pellets, fertilizers, or grain.

Figure 3-18 A nonpressurized rail tank car has visible valves and piping.

Figure 3-19 Pressurized rail tank cars have top mounted fittings for loading and unloading.

Figure 3-20 Special-use rail tank cars include boxcars, flat cars, cryogenic and corrosive tank cars. Tube cars are no longer in service.

erate long-duration, high-pressure leaks that may prove difficult to stop. For example, a liquid or vapor release from the valve arrangements on a chlorine tank car requires a special kit to stop the leak. Additionally, pressurized rail tank cars may be insulated or uninsulated depending on the material being transported.

Cryogenic tank cars are the most common special-use railcars emergency responders may encounter, although there are not many of them. Cryogenic railcars illustrate an important concept for the emergency responder: The hazard will be unique to the particular railcar and its contents Figure 3-20.

The train's engineer or conductor will have information about all the cars on the train and should be consulted during a railway emergency. Details about the shipping papers unique to railway transportation are presented later in this chapter.

## Pipelines

Of all the various methods used to transport hazardous materials, the high-volume pipeline is the one that is most rarely involved in emergencies. A pipeline is a length of pipe—including pumps, valves, flanges, control devices, strainers, and/or similar equipment—for conveying fluids and gases. Like rail incidents, pipeline incidents may present responders with challenges and hazards not typically encountered at most hazardous materials incidents. In many areas, large-diameter pipelines transport natural gas, gasoline, diesel fuel, and other products from delivery terminals to distribution facilities. Pipelines are often buried underground, but may be above ground in remote areas.

Figure 3-21 A pipeline warning sign provides information about the pipe's contents, the owner's name, and contact information.

The pipeline right-of-way is an area, patch, or roadway that extends a certain number of feet on either side of the pipe itself. The company that owns the pipeline maintains this area. The company is also responsible for placing warning signs at regular intervals along the length of the pipeline. Pipeline warning signs include a warning symbol, the pipeline owner's name, and an emergency contact phone number Figure 3-21.

Pipeline emergencies are complicated events that require specially trained responders. If you suspect an emergency involving a pipeline, contact the owner of the line immediately. The company will dispatch a crew to assist with the incident.

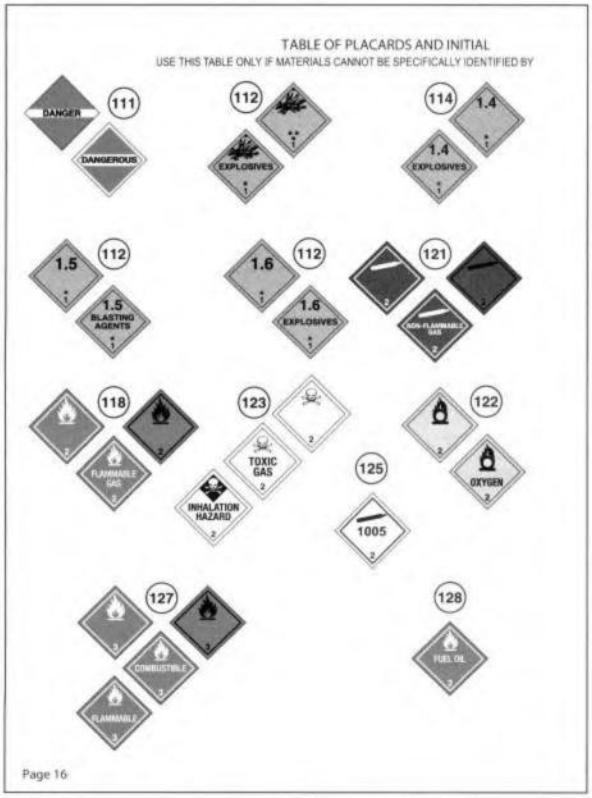
Information about the pipe's contents and owner is also often found at the vent pipes. These inverted J-shaped tubes provide pressure relief or natural venting during maintenance and repairs. Vent pipes are clearly marked and are located approximately 3 feet above the ground.

# Transportation and Facility Markings

The presence of labels, placards, and other markings on buildings, packages, boxes, and containers often enables responders to identify a released chemical. When used correctly, marking systems indicate the presence of a hazardous material and provide clues about the substance. This section provides an introduction to the various marking systems currently being used. It does not cover all the intricacies and requirements for every marking system; it will, however, acquaint you with the most common systems.

## The Department of Transportation Marking System

The U.S. Department of Transportation (DOT) marking system is an identification system characterized by labels, placards, and markings Figure 3-22.



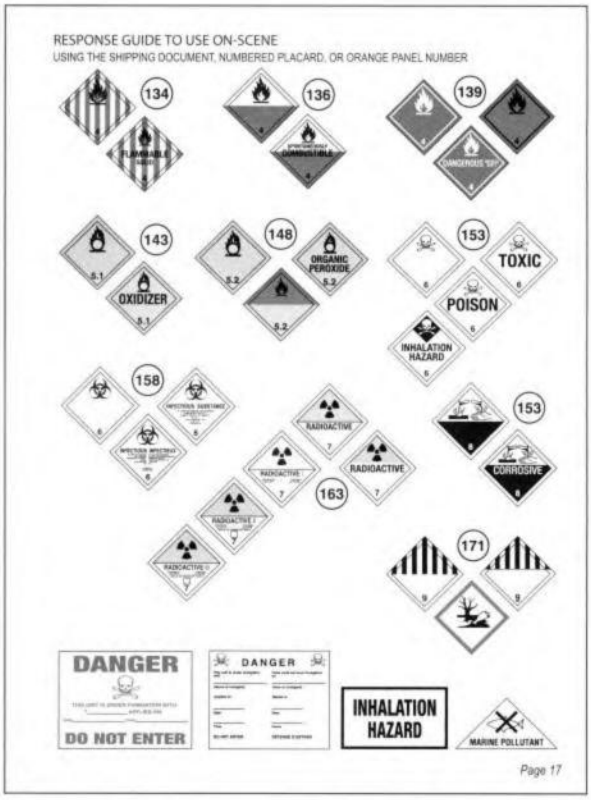




**Figure 3-22** The DOT uses labels, placards, and markings (such as these found in the *Emergency Response Guidebook*) to give responders a general idea of the hazard inside a particular container or cargo tank.

This marking system is used when materials are being transported from one location to another in the United States. The same marking system is also used in Canada by Transport Canada.

Placards are diamond-shaped indicators (10¾" on each side) that are placed on all four sides of highway transport vehicles, railroad tank cars, and other forms of transportation carrying hazardous materials **Figure 3-23**. Labels are smaller versions (4" diamond-shaped indicators) of placards; they are placed on the four sides of individual boxes and smaller packages being transported **Figure 3-24**.

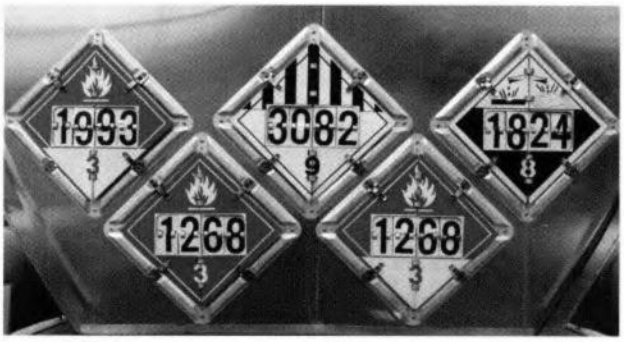



**Figure 3-23** A placard is a large diamond-shaped indicator that is placed on all sides of transport vehicles that carry hazardous materials.

Placards, labels, and markings are intended to give responders a general idea of the hazard inside a particular container or cargo tank. A placard identifies the broad hazard class (flammable, poison, corrosive) to which the material inside belongs. A label on a box inside a delivery truck, for example, relates only to the potential hazard inside that particular package.

### Other Considerations

The DOT system does not require that all chemical shipments be marked with placards or labels. In most cases, the package or cargo tank must contain a certain amount of hazardous material before a placard is required. For example, the "1000-pound rule" applies to blasting agents, flammable and nonflammable gases, flammable/combustible liquids, flammable solids, air-reactive solids, oxidizers and organic peroxides, poison solids, corrosives, and miscellaneous (class 9) materials. Placards are required for these materials only when the shipment weighs more than 1000 pounds.

Conversely, some chemicals are so hazardous that shipping any amount of them requires the use of labels or placards. These materials include explosives, poison gases, water-reactive solids, and high-level radioactive substances. A four-digit United

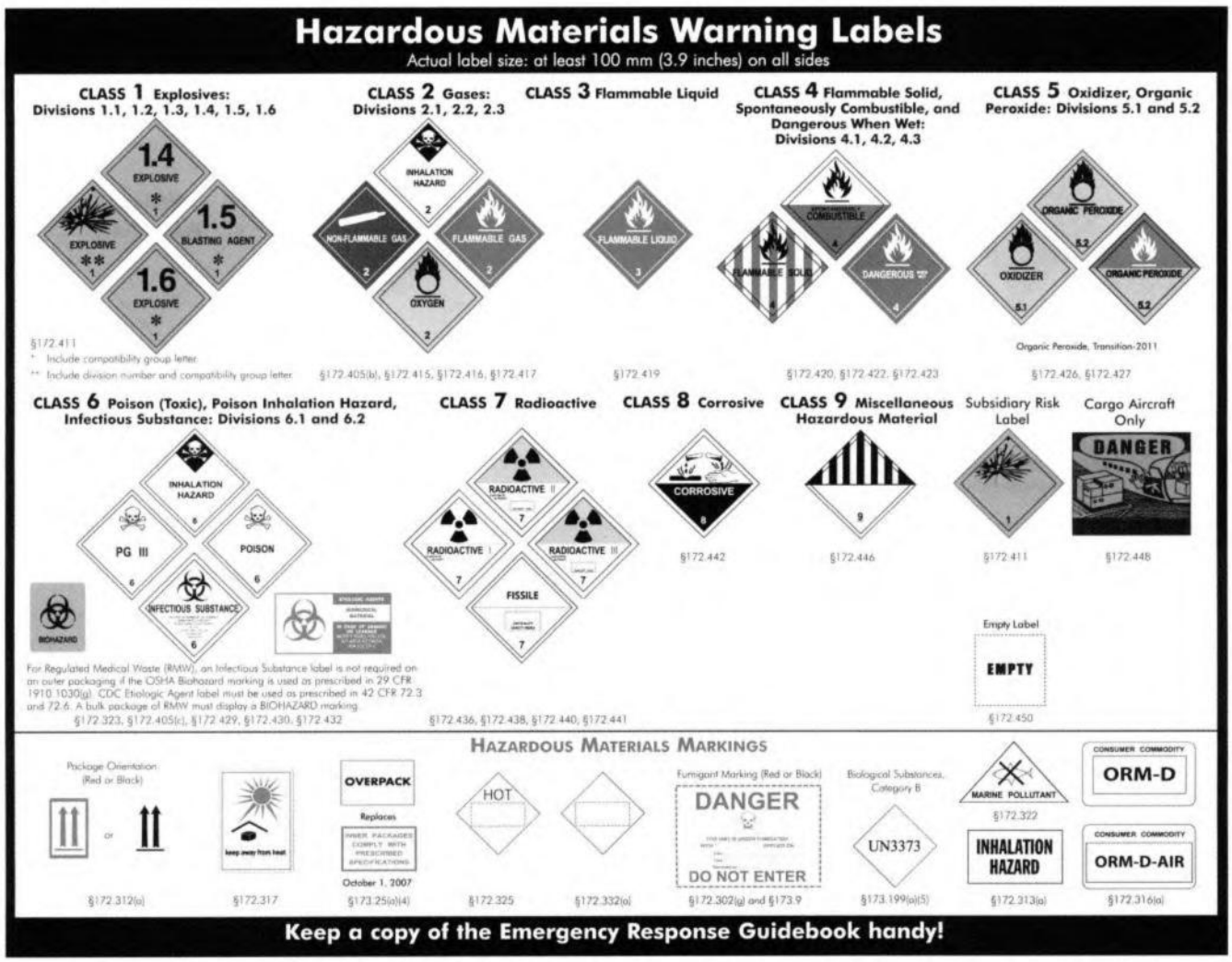



**Figure 3-24** A label is a smaller version of the placard and is placed on boxes or smaller packages that contain hazardous materials.

Nations (UN) number may be required on some placards. This number identifies the specific material being shipped; a list of UN numbers is included in the *Emergency Response Guidebook*, discussed later in this chapter.

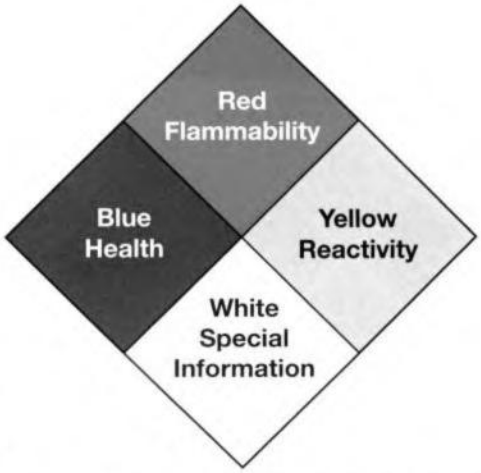
## The National Fire Protection Association 704 Marking System

The National Fire Protection Association (NFPA) has developed its own system for identifying hazardous materials. NFPA 704, *Standard System for the Identification of the Hazards of Materials for Emergency Response*, outlines a marking system characterized by a set of diamonds that are found on the outside of buildings, on doorways to chemical storage areas, and on fixed storage tanks. This marking system is designed for fixed-facility use. Responders can use the NFPA diamonds to understand the broad hazards posed by chemicals stored in a building or part of a building.

The NFPA 704 hazard identification system uses a diamond-shaped symbol of any size, which is itself broken into four smaller diamonds, each representing a particular property or characteristic **Figure 3-25 A & B ▸**. The blue diamond (at the nine o'clock position) indicates the health hazard posed by the material. The top red diamond indicates flammability. The yellow diamond (at the three o'clock position) indicates reactivity. The bottom white diamond is used for special symbols and handling instructions.

The blue, red, and yellow diamonds will each contain a numerical rating in the range of 0–4, with 0 being the least hazardous and 4 being the most hazardous **Table 3-2 ▸**. The white quadrant will not have a number but may contain special symbols. Among the symbols used are a burning O (oxidizing capability), a three-bladed trefoil (radioactivity), and a W with a slash through it (water reactive). For complete information on the NFPA 704 system, consult NFPA 704, *Standard System for the Identification of the Hazards of Materials for Emergency Response*.

A.




B.

**Figure 3-25 A & B** **A.** Example of a placard using the NFPA 704 hazard identification system that is used for fixed-facility use. **B.** Each color used in the diamond represents a particular property or characteristic.

**Table 3-2 Hazard Levels in the NFPA Hazard Identification System**

**Flammability Hazards (Red Diamond) ◆**

4 Materials that will rapidly or completely vaporize at atmospheric pressure and normal ambient temperature, or that are readily dispersed in air and that will burn readily. Liquids with a flashpoint below 73°F (22°C) and a boiling point below 100°F (38°C).

3 Liquids and solids that can be ignited under almost all ambient temperature conditions. Liquids with a flashpoint below 73°F (22°C) and a boiling point above 100°F (38°C) or liquids with a flashpoint above 73°F (22°C) but not exceeding 100°F (38°C) and a boiling point below 100°F (38°C).

2 Materials that must be moderately heated or exposed to relatively high ambient temperatures before ignition can occur. Liquids with flashpoint above 100°F (38°C) but not exceeding 200°F (93°C).

1 Materials that must be preheated before ignition can occur. Liquids that have a flashpoint above 200°F (93°C).

0 Materials that will not burn.

**Health Hazards (Blue Diamond) ◆**

4 Materials that on very short exposure could cause death or major residual injury.

3 Materials that on short exposure could cause serious temporary or residual injury.

2 Materials that on intense or continued, but not chronic, exposure could cause incapacitation or possible residual injury.

1 Materials that on exposure would cause irritation but only minor residual injury.

0 Materials that on exposure under fire conditions would offer no hazard beyond that of ordinary combustible material.

**Reactivity Hazards (Yellow Diamond) ◆**

4 Materials that in themselves are readily capable of detonation or of explosive decomposition or reaction at normal temperatures and pressures.

3 Materials that in themselves are capable of detonation or explosive decomposition or reaction but require a strong initiating source, or that must be heated under confinement before initiation, or that react explosively with water.

2 Materials that readily undergo violent chemical change at elevated temperatures and pressures, or that react violently with water, or that may form explosive mixtures with water.

1 Materials that in themselves are normally stable, but can become unstable at elevated temperatures and pressures.

0 Materials that in themselves are normally stable, even under fire exposure conditions, and are not reactive with water.

**Special Hazards (White Diamond) ◇**

| | |
|---|---|
| *ACID* | Acid |
| *ALK* | Alkali |
| *COR* | Corrosive |
| *OX* | Oxidizer |
| ~~*W*~~ | Reacts with water |

Figure 3-26 The HMIS helps employers comply with the Hazard Communication Standard.

To accurately compare and contrast the DOT marking system and NFPA 704 system, remember this important difference:

- The DOT hazardous materials marking system is used when materials are being transported from one location to another.
- The NFPA 704 hazard identification system is designed for fixed-facility use.

## Hazardous Materials Information System

Since 1983, the Hazardous Materials Information System (HMIS) hazard communication program has helped employers comply with the Hazard Communication Standard established by the U.S. Occupational Safety and Health Administration (OSHA). The HMIS is similar to the NFPA 704 marking system and uses a numerical hazard rating with similarly colored horizontal columns Figure 3-26.

The HMIS is more than just a label; it is a method used by employers to give their personnel necessary information to work safely around chemicals, and includes training materials to inform workers of chemical hazards in the workplace. The HMIS is not required by law but rather is a voluntary system that employers choose to use to comply with OSHA's Hazard Communication Standard. In addition to describing the chemical hazards posed by a particular substance, the HMIS provides guidance about the personal protective equipment that employees need to use to protect themselves from workplace hazards. Letters and icons specify the different levels and combinations of protective equipment.

Responders must understand the fundamental difference between the NFPA 704 marking system and the HMIS. NFPA 704 is intended for responders; the HMIS is intended for the employees of a facility. Although the HMIS is not a response information tool, it can give clues about the presence and nature of the hazardous materials found in the facility.

### Canadian Perspectives

The Workplace Hazardous Materials Information System (WHMIS) is the Canadian hazard communication standard. The key pieces of this system include mandated employee training programs (much like OSHA's programs), access to MSDS at the workplace, and the identification or labeling of containers that hold "controlled products."

## Military Hazardous Materials/ Weapons of Mass Destruction Markings

The U.S. military has developed its own marking system for hazardous materials. The military system serves primarily to identify detonation, fire, and special hazards.

In general, hazardous materials within the military marking system are divided into four categories based on the relative detonation and fire hazards:

- Division 1 materials are considered mass detonation hazards and are identified by a number 1 printed inside an orange octagon Figure 3-27A.
- Division 2 materials have explosion-with-fragment hazards and are identified by a number 2 printed inside an orange X Figure 3-27B.
- Division 3 materials are mass fire hazards and are identified by a number 3 printed inside an inverted orange triangle Figure 3-27C.
- Division 4 materials are moderate fire hazards and are identified by a number 4 printed inside an orange diamond Figure 3-27D.

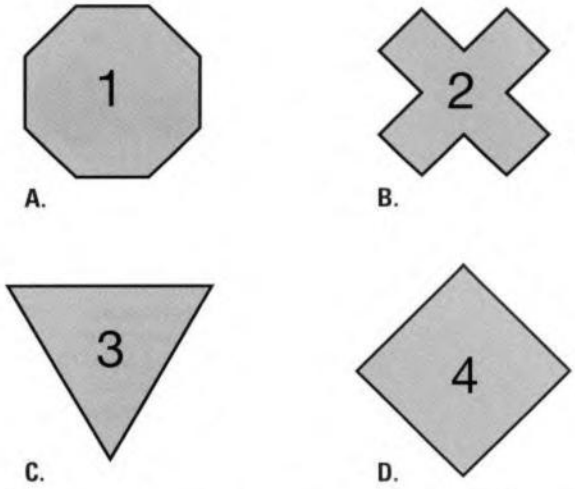



Figure 3-27A–D A. Mass detonation hazards. B. Explosion-with-fragment hazards. C. Mass fire hazards. D. Moderate fire hazards.

Chemical hazards in the military system are depicted by colors. Toxic agents (such as sarin or mustard gas) are identified by the color red. Harassing agents (such as tear gas and smoke producers) are identified by yellow. White phosphorus is identified by white. Specific personal protective gear requirements are identified using pictograms. Military shipments containing hazardous materials/WMD are not required, by exception, to be placarded.

## Chemical References

Numerous reference materials are available to the responder, including the DOT's *Emergency Response Guidebook* and Jones and Bartlett Publishers' *Fire Fighter's Handbook of Hazardous Materials*. The following sections describe these resources.

### The *Emergency Response Guidebook*

The DOT *Emergency Response Guidebook (ERG)* offers a certain amount of guidance for responders operating at a hazardous materials incident Figure 3-28. This guide, which is intended to help responders decide which preliminary action to take, provides information on approximately 4000 chemicals. The *ERG* should not be used to create a long-term action plan, however. Once the incident progresses beyond the first 15 minutes, the *ERG* is no longer an appropriate source of information. Responders at the scene should seek additional specifics about any material in question by consulting the appropriate emergency response agency or utilizing the emergency response number on a shipping document, if applicable, to gather more information.

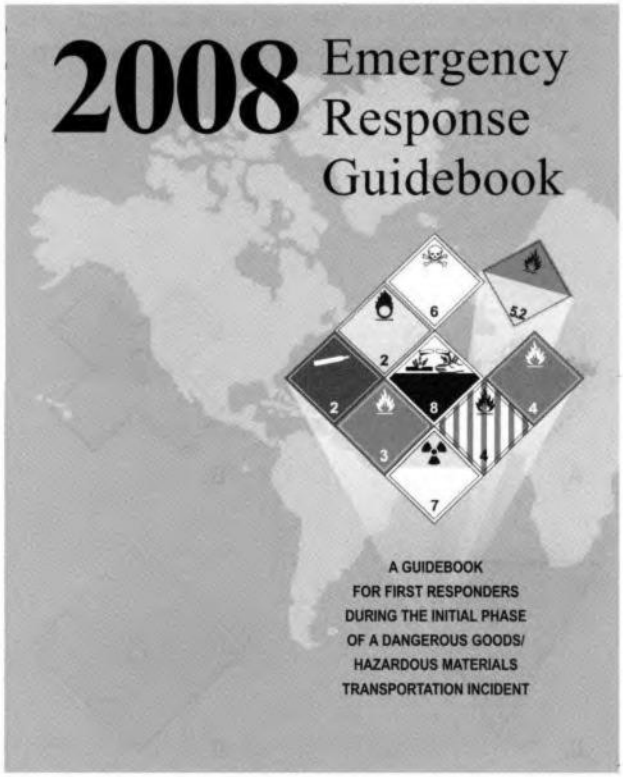



Figure 3-28 The *Emergency Response Guidebook* is a reference used as a base for your initial actions at a hazardous materials incident.

**Responder Tips**

The same information, organized differently, is found in both the blue and yellow sections of the *ERG*.

The U.S. DOT and the Secretariat of Communications and Transportation of Mexico (SCT), along with Transport Canada, jointly developed the *ERG*.

#### Using the *ERG*

When the *ERG* refers to a *small spill*, it means a leak from one small package, a small leak in a large container (up to a 55-gallon drum), a small cylinder leak, or any small leak, even one in a large package. A *large spill* is a large leak or spill from a larger container or package, a spill from a number of small packages, or anything from a 1-ton cylinder, tank truck, or railcar.

The *ERG* is divided into four colored sections: yellow, blue, orange, and green.

- Yellow section. More than 4000 chemicals are found in this section, listed numerically by their four-digit UN number/identification (ID) number. Entry number 1005, for example, identifies "ammonia, anhydrous." Use the yellow section when the UN/ID number is known or can be identified. The entries include the name of the chemical and the emergency action guide number. For example:

| ID No. | Guide No. | Name of Material |
|---|---|---|
| 1005 | 125 | Ammonia, anhydrous |

- Blue section. The same chemicals listed in the yellow section are found here, listed alphabetically by name. The entry will include the emergency action guide number and the identification number.

| Name of Material | Guide No. | ID No. |
|---|---|---|
| Ammonia, anhydrous | 125 | 1005 |

- Orange section Figure 3-29. This section is organized by guide number. The general hazard class, fire/explosion hazards, health hazards, and basic emergency actions, based on hazard class are provided.
- Green section Figure 3-30. This section is organized numerically by UN/ID number and provides the initial isolation distances for certain materials. Chemicals included in this section consist of the chemicals highlighted from the yellow and blue sections.* The green section includes water-reactive materials that produce toxic gases (calcium phosphide and trichlorosilane, for example); toxic inhalation hazards (TIH), which are

* The yellow and blue sections of the *ERG* contain the same information; it's just organized differently. Therefore, any substance highlighted in the blue section will also be highlighted in the yellow section, and vice versa.

**GUIDE 125** GASES - CORROSIVE ERG2008 ERG2008 GASES - CORROSIVE **GUIDE 125**

**POTENTIAL HAZARDS**

**HEALTH**
- **TOXIC; may be fatal if inhaled, ingested or absorbed through skin.**
- Vapors are extremely irritating and corrosive.
- Contact with gas or liquefied gas may cause burns, severe injury and/or frostbite.
- Fire will produce irritating, corrosive and/or toxic gases.
- Runoff from fire control may cause pollution.

**FIRE OR EXPLOSION**
- Some may burn but none ignite readily.
- Vapors from liquefied gas are initially heavier than air and spread along ground.
- Some of these materials may react violently with water.
- Cylinders exposed to fire may vent and release toxic and/or corrosive gas through pressure relief devices.
- Containers may explode when heated.
- Ruptured cylinders may rocket.

**PUBLIC SAFETY**
- **CALL Emergency Response Telephone Number on Shipping Paper first. If Shipping Paper not available or no answer, refer to appropriate telephone number listed on the inside back cover.**
- As an immediate precautionary measure, isolate spill or leak area for at least 100 meters (330 feet) in all directions.
- Keep unauthorized personnel away.
- Stay upwind.
- Many gases are heavier than air and will spread along ground and collect in low or confined areas (sewers, basements, tanks).
- Keep out of low areas.
- Ventilate closed spaces before entering.

**PROTECTIVE CLOTHING**
- Wear positive pressure self-contained breathing apparatus (SCBA).
- Wear chemical protective clothing that is specifically recommended by the manufacturer. It may provide little or no thermal protection.
- Structural firefighters' protective clothing provides limited protection in fire situations ONLY; it is not effective in spill situations where direct contact with the substance is possible.

**EVACUATION**

**Spill**
- See Table 1 - Initial Isolation and Protective Action Distances for highlighted materials. For non-highlighted materials, increase, in the downwind direction, as necessary, the isolation distance shown under "PUBLIC SAFETY".

**Fire**
- If tank, rail car or tank truck is involved in a fire, ISOLATE for 1600 meters (1 mile) in all directions; also, consider initial evacuation for 1600 meters (1 mile) in all directions.

**EMERGENCY RESPONSE**

**FIRE**

**Small Fire**
- Dry chemical or $CO_2$.

**Large Fire**
- Water spray, fog or regular foam.
- Move containers from fire area if you can do it without risk.
- Do not get water inside containers.
- Damaged cylinders should be handled only by specialists.

**Fire involving Tanks**
- Fight fire from maximum distance or use unmanned hose holders or monitor nozzles.
- Cool containers with flooding quantities of water until well after fire is out.
- Do not direct water at source of leak or safety devices; icing may occur.
- Withdraw immediately in case of rising sound from venting safety devices or discoloration of tank. • ALWAYS stay away from tanks engulfed in fire.

**SPILL OR LEAK**
- Fully encapsulating, vapor protective clothing should be worn for spills and leaks with no fire.
- Do not touch or walk through spilled material.
- Stop leak if you can do it without risk.
- If possible, turn leaking containers so that gas escapes rather than liquid.
- Prevent entry into waterways, sewers, basements or confined areas.
- Do not direct water at spill or source of leak.
- Use water spray to reduce vapors or divert vapor cloud drift. Avoid allowing water runoff to contact spilled material. • Isolate area until gas has dispersed.

**FIRST AID**
- Move victim to fresh air. • Call 911 or emergency medical service.
- Give artificial respiration if victim is not breathing.
- **Do not use mouth-to-mouth method if victim ingested or inhaled the substance; give artificial respiration with the aid of a pocket mask equipped with a one-way valve or other proper respiratory medical device.**
- Administer oxygen if breathing is difficult.
- Remove and isolate contaminated clothing and shoes.
- In case of contact with liquefied gas, thaw frosted parts with lukewarm water.
- In case of contact with substance, immediately flush skin or eyes with running water for at least 20 minutes.
- **In case of contact with Hydrogen fluoride, anhydrous (UN1052)**, flush skin and eyes with water for 5 minutes; then, for skin exposures rub on a calcium/jelly combination; for eyes flush with a water/calcium solution for 15 minutes.
- Keep victim warm and quiet. • Keep victim under observation.
- Effects of contact or inhalation may be delayed.
- Ensure that medical personnel are aware of the material(s) involved and take precautions to protect themselves.

*Page 196* *Page 197*

**Figure 3-29** The orange section of the *ERG*.

**TABLE 1 - INITIAL ISOLATION AND PROTECTIVE ACTION DISTANCES**

*Page 300*

| | | SMALL SPILLS (From a small package or small leak from a large package) | | | | | | LARGE SPILLS (From a large package or from many small packages) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | First ISOLATE in all Directions | | Then PROTECT persons Downwind during- | | | | First ISOLATE in all Directions | | Then PROTECT persons Downwind during- | | | |
| | | | | DAY | | NIGHT | | | | DAY | | NIGHT | |
| ID No. | NAME OF MATERIAL | Meters | (Feet) | Kilometers | (Miles) | Kilometers | (Miles) | Meters | (Feet) | Kilometers | (Miles) | Kilometers | (Miles) |
| 1005 | Ammonia, anhydrous | 30 m | (100 ft) | 0.1 km | (0.1 mi) | 0.2 km | (0.1 mi) | 150 m | (500 ft) | 0.8 km | (0.5 mi) | 2.3 km | (1.4 mi) |
| 1005 | Anhydrous ammonia | | | | | | | | | | | | |

**Figure 3-30** The green section of the *ERG*.

gases or volatile liquids that are extremely toxic to humans; chemical warfare agents (CWA); and dangerous water-reactive materials (WRM). Examples include such substances as anhydrous ammonia, sarin, and sodium cyanide. These gases or volatile liquids are extremely toxic to humans and pose a hazard to health during transport. Any material listed in the green section is extremely hazardous.

To use the *ERG*, follow the steps in **Skill Drill 3-1** (NFPA 472, 4.1.2.2, 4.2.3, 4.4.1, 5.2.3):

1. Identify the chemical name and/or the chemical ID number for the suspect material.
2. Look up the material name in the appropriate section. Use the yellow section to obtain information based on the chemical ID number. Use the blue section to obtain information based on the alphabetical chemical name. *Note any highlights.*
3. Determine the correct emergency action guide to use for the chemical identified.

**Responder Safety Tips**

Any substance highlighted, in either the yellow or blue section of the *ERG*, is either a toxic inhalation hazard, a chemical warfare agent, or a water-reactive material.

Figure 3-31 A dangerous placard indicates that more than one hazard is contained within the same load.

4. Identify the potential fire and explosion and/or health hazards of the chemical identified.
5. Identify the isolation distance and the protective actions required for the chemical identified.
6. Identify the emergency response actions of the chemical identified.

The *ERG* organizes chemicals into nine basic hazard classes, or families; the members of each family exhibit similar properties. There is also a "Dangerous" placard, which indicates that more than one hazard class is contained in the same load Figure 3-31.

The nine chemical families, and their respective divisions recognized in the *ERG*, are outlined here:

- DOT Class 1—Explosives
  - Division 1.1 Explosives with a mass explosion hazard
  - Division 1.2 Explosives with a projection hazard
  - Division 1.3 Explosives with predominately a fire hazard
  - Division 1.4 Explosives with no significant blast hazard
  - Division 1.5 Very insensitive explosives with a mass explosion hazard
  - Division 1.6 Extremely insensitive articles
- DOT Class 2—Gases
  - Division 2.1 Flammable gases
  - Division 2.2 Nonflammable, nontoxic gases
  - Division 2.3 Toxic gases
- DOT Class 3—Flammable liquids (and combustible liquids in the United States)
- DOT Class 4—Flammable solids; spontaneously combustible materials; and dangerous when wet materials/water-reactive substances
  - Division 4.1 Flammable solids
  - Division 4.2 Spontaneously combustible materials
  - Division 4.3 Water-reactive substances/dangerous when wet
- DOT Class 5—Oxidizing substances and organic peroxides
  - Division 5.1 Oxidizing substances
  - Division 5.2 Organic peroxides
- DOT Class 6—Toxic* substances and infectious substances
  - Division 6.1 Toxic substances
  - Division 6.2 Infectious substances
- DOT Class 7—Radioactive materials
- DOT Class 8—Corrosive substances
- DOT Class 9—Miscellaneous hazardous materials/products, substances. or organisms

Table 3-3 provides examples of substances emergency responders should be aware of, along with their UN hazard class designations.

**Table 3-3 Corresponding UN/DOT Hazard Classes and Divisions**

| Common Name | UN/DOT Hazard Class/Division |
|---|---|
| **Blood Agents** | |
| Hydrogen cyanide | 6.1 |
| Cyanogen chloride | 2.3 |
| **Biological Agents and Toxins** | |
| Smallpox | 6.2 |
| Ricin | 6.2 |
| Anthrax | 6.2 |
| **Choking Agents** | |
| Chlorine | 2.3 |
| Phosgene | 2.3 |
| **Irritants (Riot Control Agents)** | |
| Pepper spray, mace | 2.2 (subsequent risk 6.1) |
| Tear gas | 6.1 |
| Mace | 6.1 |
| **Nerve Agents** | |
| Sarin | 6.1 |
| Soman | 6.1 |
| Tabun | 6.1 |
| V agent | 6.1 |
| **Radiological Materials** | 7 |
| **Vesicants (Blister Agents)** | |
| Mustard | 6.1 |
| Lewisite | 6.1 |
| Nitrogen mustard | 6.1 |

## Fire Fighter's Handbook of Hazardous Materials

Emergency responders also use numerous other chemical reference manuals. For example, the *Fire Fighter's Handbook of Hazardous Materials*, seventh edition, is similar to the *ERG* Figure 3-32. This handbook contains more than 13,000 chemicals along with their critical characteristics. The handbook lists chemicals in alphabetical order and provides a listing of the basic properties for each chemical in a spreadsheet format. The spreadsheet also provides emergency guides. The handbook also provides a listing of chemicals based on their DOT ID numbers.

* The words "poison" and "poisonous" are synonymous with the word "toxic."

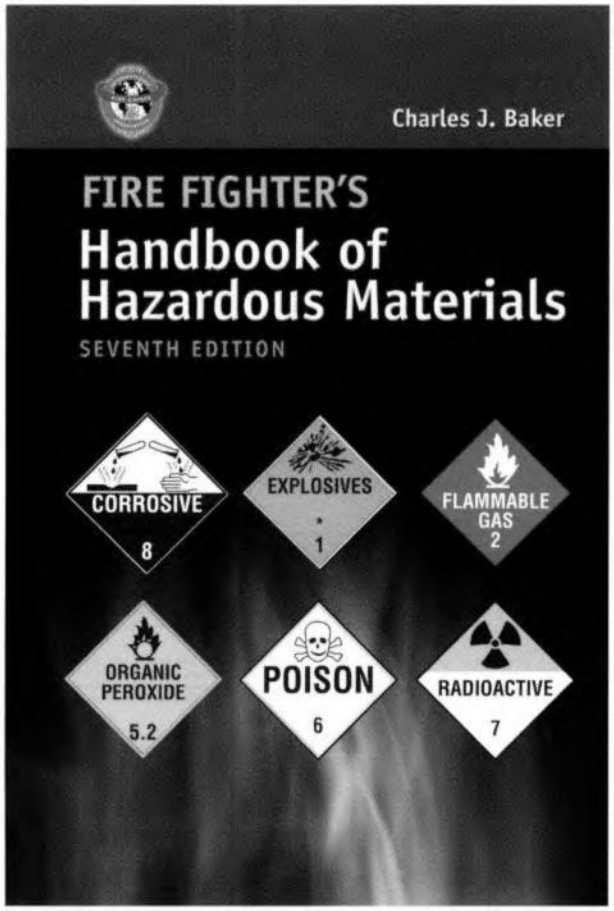



Figure 3-32 *Fire Fighter's Handbook of Hazardous Materials*, seventh edition, is another reference that can be used as a base for your initial actions at a hazardous materials incident.

**Responder Tips**

The responder should always attempt to identify hazardous materials using more than one source. The *ERG* is only one source and should not be used exclusively.

Fire fighters, police, and other emergency services personnel—all of whom may be the first to arrive at the scene of a transportation incident involving a hazardous material—are the primary audience for both the *ERG* and the *Fire Fighter's Handbook of Hazardous Materials*.

## Other Reference Sources

Labels and placards may be helpful in identifying hazardous materials, but other sources of information are also available. Among these reference sources are material safety data sheets (MSDS), shipping papers, and staffed national resource centers. First-responding fire fighters, law enforcement personnel, or representatives of other allied agencies should place a high priority on identifying the released material and finding a reliable source of information about the chemical and physical properties of the released substance. The most appropriate source will depend on the situation; use your best judgment in making your selection.

### Material Safety Data Sheets

A common source of information about a particular chemical is the MSDS specific to that substance Figure 3-33. Essentially, an MSDS provides basic information about the chemical makeup of a substance, the potential hazards it presents, appropriate first aid in the event of an exposure, and other pertinent data for safe handling of the material. An MSDS will typically include the following details:

- The name of the chemical, including any synonyms
- Physical and chemical characteristics of the material
- Physical hazards of the material
- Health hazards of the material
- Signs and symptoms of exposure
- Routes of entry
- Permissible exposure limits
- Responsible-party contact
- Precautions for safe handling (including hygiene practices, protective measures, and procedures for cleaning up spills or leaks)
- Applicable control measures, including personal protective equipment
- Emergency and first-aid procedures
- Appropriate waste disposal

When responding to a hazardous materials incident at a fixed facility, responders should ask the site representative for an MSDS for the spilled material. All facilities that use or store chemicals are required by law to have an MSDS on file for each chemical used or stored in the facility. Many sites, but especially those that stock many different chemicals, may keep this information archived on a computer database. Although the MSDS is not a definitive response tool, it is a key piece of the puzzle. Responders should investigate as many sources as possible (preferably at least three) to gather emergency information about a released substance. A MSDS can also be obtained from staffed national resource centers or on the transporting vehicle.

### Shipping Papers

Shipping papers are required whenever materials are transported from one place to another. They include the names and addresses of the shipper and the receiver, identify the material being shipped, and specify the quantity and weight of each part of the shipment. Shipping papers for road and highway transportation are called bills of lading or freight bills and are located in the cab of the vehicle Figure 3-34. Drivers transporting chemicals are required by law to have a set of shipping papers on their person or within easy reach inside the cab at all times.

A bill of lading may provide additional information about a hazardous substance, such as its packaging group designation. The packaging group designation is another system used by shippers to identify special handling requirements or

## MATERIAL SAFETY DATA SHEET
### ANHYDROUS AMMONIA

TI

DISTRIBUTORS:

TANNER INDUSTRIES, INC.

**DIVISIONS**:

| | |
|---|---|
| NATIONAL AMMONIA | NORTHEASTERN AMMONIA |
| HAMLER INDUSTRIES | BOWER AMMONIA & CHEMICAL |

735 Davisville Road, Third Floor, Southampton, PA 18966; 215-322-1238

**CORPORATE EMERGENCY TELEPHONE NUMBER: 800-643-6226 CHEMTREC: 800-424-9300**

**DESCRIPTION**

**CHEMICAL NAME**: Ammonia, Anhydrous **CAS REGISTRY NO:** 7664-41-7
**SYNONYMS**: Ammonia **CHEMICAL FAMILY**: Inorganic Nitrogen Compound
**FORMULA**: $NH_3$ **MOL. WT**: 17.03 ($NH_3$) **COMPOSITION**: 99+% Ammonia

**STATEMENT OF HEALTH HAZARD**

**HAZARD DESCRIPTION**:
Ammonia is an irritant and corrosive to the skin, eyes, respiratory tract and mucous membranes. Exposure to liquid or rapidly expanding gases may cause severe chemical burns and frostbite to the eyes, lungs and skin. Skin and respiratory related diseases could be aggravated by exposure.
Not recognized by OSHA as a carcinogen.
Not listed in the National Toxicology Program.
Not listed as a carcinogen by the International Agency for Research on Cancer.

**EXPOSURE LIMITS FOR AMMONIA**: Vapor

| | | | |
|---|---|---|---|
| OSHA | 50 ppm, | 35 mg / m³ PEL | 8 hour TWA |
| NIOSH | 35 ppm, | 27 mg / m³ STEL 15 minutes | |
| | 25 ppm, | 18 mg / m³ REL | 10 hour TWA |
| | 300 ppm, | IDLH | |
| ACGIH | 25 ppm, | 18 mg / m³ TLV | 8 hour TWA |
| | 35 ppm, | 27 mg / m³ STEL 15 minutes | |

**TOXICITY**: LD 50 (Oral / Rat) 350 mg / kg

**PHYSICAL DATA**

**BOILING POINT**: -28°F at 1 Atm.
**PH**: N/A
**SPECIFIC GRAVITY OF GAS (air = 1)**: 0.596 at 32°F
**SPECIFIC GRAVITY OF LIQUID (water = 1)**: 0.682 at 28°F (Compared to water at 39°F).
**PERCENT VOLATILE**: 100% at 212°F
**APPEARANCE AND ODOR**: Colorless liquid or gas with pungent odor.
**CRITICAL TEMPERATURE**: 271.4°F
**GAS SPECIFIC VOLUME**: 20.78 Ft³/Lb at 32°F and 1 Atm.
**VAPOR DENSITY**: 0.0481 Lb/Ft³ at 32°F
**LIQUID DENSITY**: 38.00 Lb/Ft³ at 70°F
**APPROXIMATE FREEZING POINT**: -108°F
**WEIGHT (per gallon)**: 5.15 pounds at 60°F
**VAPOR PRESSURE**: 114 psig at 70°F
**SOLUBILITY IN WATER (per 100 pounds of water)**: 86.9 pounds at 32°F, 51 pounds at 68°F
**SURFACE TENSION**: 23.4 Dynes / cm at 52°F
**CRITICAL PRESSURE**: 111.5 atm



## MATERIAL SAFETY DATA SHEET
### EMERGENCY TREATMENT

**EFFECTS OF OVEREXPOSURE**:
*Eye*: Tearing, edema or blindness may occur.
*Skin*: Irritation, corrosive burns, blister formation may result. Contact with liquid may produce a caustic burn and frostbite.
*Inhalation*: Acute exposure may result in severe irritation of the respiratory tract, bronchospasm, pulmonary edema or respiratory arrest.
*Ingestion*: Lung irritation and pulmonary edema may occur. ***Extreme exposure may result in death from spasm, inflammation or edema. Brief inhalation exposure to 5,000 ppm may be fatal.***

**EMERGENCY AID**: **Remove patient to uncontaminated area.**
*Eye*: Flush with copious amounts of tepid water for a minimum of 20 minutes. Eyelids should be held apart and away from eyeball for thorough rinsing.
*Skin*: Flush with copious amounts of tepid water for a minimum of 20 minutes while removing contaminated clothing, jewelry and shoes. Do not rub or apply ointment on affected area. Clothing may initially freeze to skin. Thaw frozen clothing from skin before removing.
*Inhalation*: Remove to fresh air. If not breathing, administer artificial respiration. If trained to do so, administer supplemental oxygen, if required.
*Ingestion*: If conscious, give large amounts of water to drink. May drink orange juice, citrus juice or diluted vinegar (1:4) to counteract ammonia. If unconscious, do not give anything by mouth. **Do not induce vomiting!**

**SEEK IMMEDIATE MEDICAL HELP FOR ALL EXPOSURES!**

***NOTE TO PHYSICIAN*: Respiratory injury may appear as a delayed phenomenon. Pulmonary edema may follow chemical bronchitis. Supportive treatment with necessary ventilation actions, including oxygen, may warrant consideration.**

**FIRE AND EXPLOSION HAZARD DATA**

**FLASHPOINT**: None.
**FLAMMABLE LIMITS IN AIR**: LEL/UEL 16% to 25%.(listed in the *NIOSH Pocket Guide to Chemical Hazards* 15% to 28%).
**EXTINGUISHING MEDIA**: Dry Chemical, $CO_2$, water spray or alcohol-resistant foam if gas flow cannot be stopped.
**AUTO IGNITION TEMPERATURE**: 1,204°F (If catalyzed). 1,570°F (If un-catalyzed).

**SPECIAL FIRE-FIGHTING PROCEDURES**
Must wear protective clothing and a positive pressure SCBA. Stop source if possible. If a portable container (such as a cylinder or trailer) can be moved from the fire area without risk to the individual, do so to prevent the pressure relief valve of the trailer from discharging or the cylinder from rupturing. Fight fires using dry chemical, carbon dioxide, water spray or alcohol-resistant foam. Cool fire exposed containers with water spray. Stay upwind when containers are threatened. Use water spray to knock down vapor and dilute.

**UNUSUAL FIRE AND EXPLOSION HAZARDS**
Outdoors, ammonia is not generally a fire hazard. Indoors, in confined areas, ammonia may be a fire hazard, especially if oil and other combustible materials are present. Combustion may form toxic nitrogen oxides.
If relief valves are inoperative, heat exposed storage containers may become explosion hazards due to over pressurization.

**CHEMICAL REACTIVITY**

**STABILITY**:
Stable at room temperature. Heating a closed container above room temperature causes vapor pressure to increase rapidly.
Anhydrous ammonia will react exothermically with acids and water. Will not polymerize.

**CONDITIONS TO AVOID**
Anhydrous ammonia has potentially explosive reactions with strong oxidizers. Anhydrous ammonia forms explosive mixtures in air with hydrocarbons, chlorine, fluorine and silver nitrate. Anhydrous ammonia reacts to form explosive products, mixtures or compounds with mercury, gold, silver, iodine, bromine and silver oxide. Avoid anhydrous ammonia contact with chlorine, which forms a chloramine gas, which is a primary skin irritant and sensitizer. Avoid anhydrous ammonia contact with galvanized surfaces, copper, brass, bronze, aluminum alloys, mercury, gold and silver. A corrosive reaction will occur.

**HAZARDOUS DECOMPOSITION PRODUCTS**
Anhydrous ammonia decomposes to hydrogen and nitrogen gases above 450°C (842°F). Decomposition temperatures may be lowered by contact with certain metals, such as iron, nickel and zinc and by catalytic surfaces such as porcelain and pumice.



## MATERIAL SAFETY DATA SHEET
### SPILL OR LEAK PROCEDURES

**STEPS TO BE TAKEN**:
Stop source of leak if possible, provided it can be done in a safe manner. Leave the area of a spill by moving laterally and upwind. Isolate the affected area. Non-responders should evacuate the area, or shelter in place. Only properly trained and equipped persons should respond to an ammonia release. Wear eye, hand and respiratory protection and protective clothing; see PROTECTIVE EQUIPMENT. Stay upwind and use water spray downwind of container to absorb the evolved gas. Contain spill and runoff from entering drains, sewers, and water systems by utilizing methods such as diking, containment, and absorption. CAUTION: ADDING WATER DIRECTLY TO LIQUID SPILLS WILL INCREASE VOLATILIZATION OF AMMONIA, THUS INCREASING THE POSSIBILITY OF EXPOSURE.

**WASTE DISPOSAL**:
Listed as hazardous substance under CWA (40 CFR 116.4, 40 CFR 117.3). Reportable Quantity 100 pounds. Classified as hazardous waste under RCRA (40CFR 261.22 Corrosive #D002). Comply with all regulations. Suitably diluted product may be disposed of on agricultural land as fertilizer. Keep spill from entering streams, lakes, or any water systems.

**SPECIAL PROTECTION AND PROCEDURES**

**RESPIRATORY PROTECTION**:
Respiratory protection approved by NIOSH/MSHA for ammonia must be used when applicable safety and health exposure limits are exceeded. For escape in emergencies, MSHA/NIOSH approved respiratory protection that consists of a full-face gas mask and canisters approved for ammonia is required. Refer to 29 CFR 1910.134 and ANSI Z88.2 for requirements and selection. A positive pressure SCBA is required for entry into ammonia atmospheres at or above 300 ppm (IDLH).

**EYE PROTECTION**: Chemical splash goggles should be worn when handling anhydrous ammonia. A face shield can be worn over chemical splash goggles as additional protection. Do not wear contact lenses when handling anhydrous ammonia.

**VENTILATION**:
Local exhaust should be sufficient to keep ammonia vapor to 25 ppm or less.

**PROTECTIVE EQUIPMENT**:
At a minimum, splash proof, chemical safety goggles, ammonia resistant, gloves (such as rubber), and ammonia-impervious clothing should be worn to prevent contact during normal loading, unloading and transfer operations and handling small spills. Face shield and boots can be worn as additional protection.
Respiratory protection approved by NIOSH/MSHA for ammonia must be used when applicable safety and health exposure limits are exceeded. For a hazardous material release response, Level A and/or Level B ensemble including positive-pressure SCBA should be used. A positive pressure SCBA is required for entry into ammonia atmospheres at or above 300 ppm (IDLH). Refer to 29 CFR 1910.132 through 1910.138 for personal protective equipment requirements.

**SPECIAL PRECAUTIONS**

**STORAGE AND HANDLING**:
Only trained persons should handle anhydrous ammonia. Store in cool (26.7°C / 80°F) and well-ventilated areas, with containers tightly closed. OSHA 29 CFR 1910.111 prescribes handling and storage requirements for anhydrous ammonia as a hazardous material. Use only stainless steel, carbon steel or black iron for anhydrous ammonia containers or piping. Do not use plastic. Do not use any non-ferrous metals such as copper, brass, bronze, aluminum, tin, zinc or galvanized metals. Protect containers from physical damage. Keep away from ignition sources, especially in indoor spaces.

**WORK-PLACE PROTECTIVE EQUIPMENT**:
Protective equipment should be stored near, but outside of anhydrous ammonia area. Water for first aid, such as an eyewash station and safety shower, should be kept available in the immediate vicinity. See 29 CFR 1910.111 for workplace requirements.

**DISPOSAL**:
See WASTE DISPOSAL. Classified as RCRA Hazardous Waste due to corrosivity with designation D002, if disposed of in original form.



## MATERIAL SAFETY DATA SHEET
### LABELING AND SHIPPING

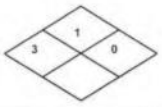
**HAZARD CLASS**: (US Domestic): 2.2 (Non-Flammable Gas) (International): 2.3 (Poison Gas) subsidiary 8 (Corrosive)

**PROPER SHIPPING DESCRIPTION**:
(US Domestic): Ammonia, Anhydrous, 2.2, UN1005, RQ, Inhalation Hazard
(International): Ammonia, Anhydrous, 2.3, (8), UN1005, RQ, Poison-Inhalation Hazard Zone "D"

**PLACARD**:
(US Domestic): Non-Flammable Gas
(International): Poison Gas, Corrosive (Subsidiary)

**IDENTIFICATION NUMBER**: UN 1005

**National Fire Protection Assoc. Hazardous Rating**:




**Hazardous Materials Identification System Labels**:

| ANHYDROUS AMMONIA | |
|---|---|
| HEALTH | 3 |
| FLAMMABILITY | 1 |
| REACTIVITY | 0 |
| PERSONAL PROTECTION | H |

**OTHER REGULATORY REQUIREMENTS**

Under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), Section 103, any environmental release of this chemical equal to or over the reportable quantity of 100 lbs. must be reported promptly to the National Response Center, Washington, D.C. (1-800-424-8802).

The material is subject to the reporting requirements of Section 304, Section 312 and Section 313, Title III of the Superfund Amendments and Reauthorization Act (SARA) of 1986 and 40 CFR 372. Emergency Planning & Community Right to Know Act, (EPCRA) extremely hazardous substance, 40 CFR 355, Title III, Section 302 – Ammonia, Threshold Planning Quantity (TPQ) 500 lbs.

EPA Hazard Categories - Immediate: Yes; Delayed: No; Fire: No; Sudden Release: Yes; Reactive: No.

Clean Air Act – Section 112(r): Material is listed under EPA's Risk Management Program (RMP), 40 CFR Part 68, at storage/process amounts greater than the Threshold Quantity (TQ) of 10,000 lbs.

**DISCLAIMER**

The information, data, and recommendations in this material safety data sheet relate only to the specific material designated herein and do not relate to use in combination with any other material or in any process. The information, data, and recommendations set forth herein are believed by us to be accurate. We make no warranties, either expressed or implied, with respect thereto and assume no liability in connection with any use of such information, data, and recommendations.



**Figure 3-33** An example of an MSDS for anhydrous ammonia.

STRAIGHT BILL OF LADING
ORIGINAL - NOT NEGOTIABLE

BOL/Reference No.
RS82715

CARRIER: NORFOLK SOUTHERN

Date: 12/23/2008

Shipper: RSI LOGISTICS, INC (OKEMOS, MI US)

The property described below, in apparent good order, except as noted (contents and condition of packages unknown), marked, consigned, and destined as indicated below, with said carrier (the word carrier being understood throughout this contract as meaning any person or corporation in possession of the property under the contract) agrees to carry to its usual place of delivery at said destination, if on its route, otherwise to deliver to another carrier on the route to said destination. It is mutually agreed, as to each carrier of all or any said property, that every service to be performed hereunder shall be subject to all the terms and conditions of the Uniform Domestic Straight Bill of Lading set forth (1) in Official, Southern, Western and Illinois Freight Classifications in effect on the date hereof, if this is a rail or rail-water shipment, or (2) in the applicable motor carrier classification or tariff if this is a motor carrier shipment.
Shipper hereby certifies that he is familiar with all the terms and conditions in the said bill of lading, including those on the back thereof, set forth in the classification or tariff which governs the transportation of this shipment, and the said terms and conditions are hereby agreed to by the shipper and accepted for himself and his assigns.

Consignee Information: (CONSIGNEE DEER PARK, TX
Address:
City: DEER PARK, TX US

Route: NS-ESTL-BNSF

Origin Switch Route:

Destination Switch Route: HUSTN-PTRA

Rail Car No: GATX290861

For assistance in any transportation emergency involving chemicals, phone CHEMTREC, day or night, Toll Free 1-800-424-9300

| DESCRIPTION | | *WEIGHT |
|---|---|---|
| ONE TANK CAR | Contains:<br>Methyl Esters,<br>STCC#2899415<br>BIODIESEL-15, Biodiesel<br><br>Sales Order Contract No: RS82715<br>Sales Order Contract No: AAT122308-4<br>Purchase Order Contract No: AAT122308-4 | (Sub. To Correction)<br>204400 Lbs. |

SEAL NUMBERS:

Gross

Tare

Net

Weighed By: _____

If charges are to be prepaid, write or stamp here, "To be Prepaid"
Prepaid

Subject to Section 7 of the conditions of applicable bill of lading, if this shipment is to be delivered to the consignee without recourse on the consignor, the consignor shall sign the following statement: The carrier shall not make delivery of this shipment without payment of freight and all other lawful charges.

Not In Effect

* This is to certify that the above named materials are properly classified, described, packaged, marked, and labeled, and are in proper condition for transportation, according to the applicable regulations of the Department of Transportation.

**Figure 3-34** A bill of lading or freight bill.

WAYBILL
NON-NEGOTIABLE

WAYBILL NO.

1 - SHIPPER'S COPY

**Figure 3-35** A waybill.

**CARGO MANIFEST**

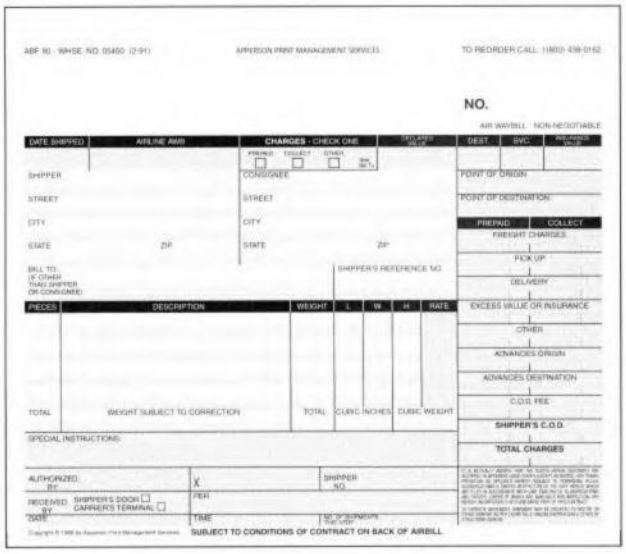
| AIR | AIRCRAFT DATA: CARRIER | A/C NO. | A/C MODEL | DEST CODE | REF | DESTINATION | MISSION DATA: NO. | SU | DATE | ALW WT | ALW CU | MANIFEST ID: STA | FY | TY | NO. | PAGE NO. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SURFACE | POE | DATE SAILED | VOYAGE DOCUMENT NO. | POD | REF | VESSEL NAME | STATUS | SUST | TRUCK NO. | REMARKS | | | | | | PAGE NO. |

| DOC ID | VEHICLE TRAILER OR CNTNR NUMBER | YR / MAKE / CNTNR NUMBER / COMMODTY DESCRIP | COM CODE | CARGO EXC | AIRDM | VOYAGE DOC NO. / TRNS PT | PORT OF DISCH | TYPE PACK | TRANSPORTATION CONTROL NUMBER | CONSIGNEE: SERV | ACTVTY ADDRESS | PRIORITY | NAME / AMMO LOT NO./NOMEN / DIMENSIONS: RDD | PROJ | STOW LOC | TRANS ACCT | IDENTIFICATION NO. OR REMARKS | PIECES | WEIGHT | CUBE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | | | | | | |

| ITEMS HAVE BEEN LOADED: | | ITEMS HAVE BEEN RECEIVED EXCEPT AS CIRCLED NOTED ON REVERSE SIDE | | | TOTALS | 0 | 0.00 | 0.00 |
|---|---|---|---|---|---|---|---|---|
| DATE | SIGNATURE OF LOADING AGENT | DATE | SIGNATURE OF UNLOADING AGENT | DATE | SIGNATURE OF RECEIVING AGENT | | | |

DD FORM 1385, NOV 78 REPLACES EDITION OF 1 APR 66 WHICH MAY BE USED Adobe Professional 7.0

**Figure 3-36** Dangerous cargo manifest.


ABF 90 - WHSE NO. 05450 (2-91) APPERSON PRINT MANAGEMENT SERVICES TO REORDER CALL: 1(800) 439-0152

NO.

AIR WAYBILL - NON-NEGOTIABLE

| DATE SHIPPED | AIRLINE AWB | CHARGES - CHECK ONE | DECLARED VALUE | DEST. | SVC. | DECLARED VALUE |
|---|---|---|---|---|---|---|
| | | PREPAID ☐ COLLECT ☐ OTHER ☐ | | | | |

SHIPPER
STREET
CITY
STATE ZIP

CONSIGNEE
STREET
CITY
STATE ZIP

POINT OF ORIGIN
POINT OF DESTINATION

BILL TO: (IF OTHER THAN SHIPPER OR CONSIGNEE)

SHIPPER'S REFERENCE NO.

| PREPAID | COLLECT |
|---|---|
| FREIGHT CHARGES | |
| PICK UP | |
| DELIVERY | |
| EXCESS VALUE OR INSURANCE | |
| OTHER | |
| ADVANCES ORIGIN | |
| ADVANCES DESTINATION | |
| C.O.D. FEE | |
| SHIPPER'S C.O.D. | |
| TOTAL CHARGES | |

| PIECES | DESCRIPTION | WEIGHT | L | W | H | RATE |
|---|---|---|---|---|---|---|
| TOTAL | WEIGHT SUBJECT TO CORRECTION | TOTAL | CUBIC INCHES | CUBIC WEIGHT | | |

SPECIAL INSTRUCTIONS

AUTHORIZED BY X SHIPPER NO.
RECEIVED BY SHIPPER'S DOOR ☐ CARRIER'S TERMINAL ☐ PER
DATE TIME NO. OF CONTINUOUS PAGES

SUBJECT TO CONDITIONS OF CONTRACT ON BACK OF AIRBILL

**Figure 3-37** An air bill.

## Canadian Perspectives

Transport Canada is the focal point for the Canadian national program to promote public safety during the transportation of dangerous goods. The department's Transport Dangerous Goods Directorate serves as the major source of regulatory development, information, and guidance on dangerous goods transport for the public, industry, and government employees. This Directorate also works closely with other federal and provincial agencies to implement safety programs. The Canadian Transport Emergency Center (CANUTEC) is operated by Transport Canada to assist emergency response personnel in handling hazardous materials emergencies. Established in 1979, CANUTEC responds to more than 30,000 calls per year, ranging from information requests to emergency notifications.

The Canadian Centre for Occupational Health and Safety (CCOHS) promotes a safe and healthy working environment by providing information and advice about occupational health and safety.

The Canadian federal Hazardous Products Act defines which materials (i.e., controlled products) are included in the Workplace Hazardous Materials Information System (WHMIS) and what information suppliers must provide to employers for controlled products used in the workplace through MSDS documentation.

hazards. Some DOT hazard classes require shippers to assign packaging groups based on the material's flash point and toxicity. A packaging group designation may signal that the material poses a greater hazard than similar materials in a hazard class. There are three packaging group designations:

- Packaging group I: high danger
- Packaging group II: medium danger
- Packaging group III: minor danger

Shipping papers for railroad transportation are called waybills **Figure 3-35**; a list of the contents in every car on the train is called a consist. The conductor, engineer, or a designated member of the train crew will have a copy of both the waybill and the consist.

On a marine vessel, shipping papers are called the dangerous cargo manifest **Figure 3-36**. The manifest is generally kept in a tube-like container in the wheelhouse in the custody of the captain or master.

For air transport, the air bill is the shipping paper **Figure 3-37**. It is kept in the cockpit and is the pilot's responsibility.

The responsible person in each situation should maintain the information about hazardous cargo and provide it in an emergency situation.

## CHEMTREC

Located in Arlington, Virginia, the Chemical Transportation Emergency Center (CHEMTREC), now operated by the American Chemistry Council, is a clearinghouse of technical chemical information. Since 1971, this emergency call center has served as an invaluable information resource for first responders of all disciplines who are called upon to respond to chemical incidents. The toll-free number for CHEMTREC is 1-800-262-8200. CHEMTREC has the ability to provide responders with technical chemical information via telephone, fax, or other electronic media. It also offers a phone conferencing service that will put a responder in touch with thousands of shippers, subject matter experts, and chemical manufacturers.

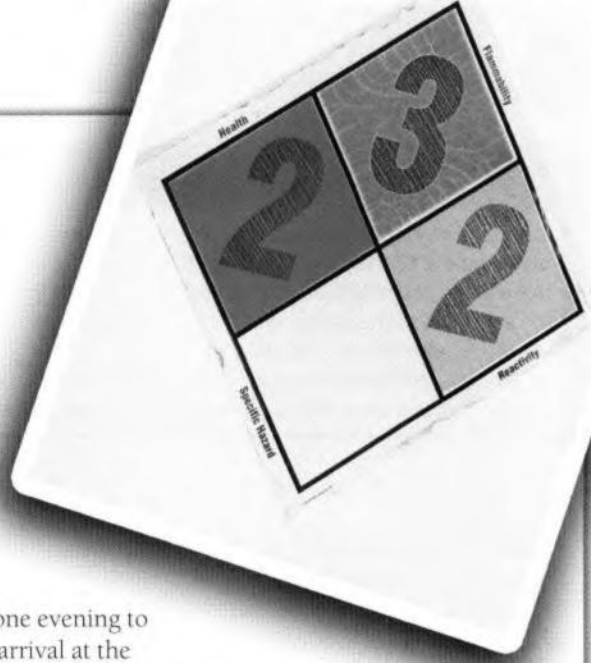
When calling CHEMTREC, be sure to have the following basic information ready:

- The name of the chemical(s) involved in the incident (if known)
- Name of the caller and callback telephone number
- Location of the actual incident or problem
- Shipper or manufacturer of the chemical (if known)
- Container type
- Railcar or vehicle markings or numbers
- The shipping carrier's name
- Recipient of material
- Local conditions and exact description of the situation

When speaking with CHEMTREC personnel, spell out all chemical names; if using a third party, such as a dispatcher, it is vital that you confirm all spellings to avoid misunderstandings. One number or letter out of place could throw off all subsequent research. When in doubt, be sure to obtain clarification.

The Canadian equivalent of CHEMTREC is the Canadian Transport Emergency Centre (CANUTEC), which is located in Ottawa. This organization serves Canadian responders (in French and English) in much the same way that CHEMTREC serves responders in the United States. CANUTEC may be called collect at 1-613-996-6666 (available 24 hours a day) for emergency situations. In a nonemergency situation, call the information line at 1-613-992-4624 (available 24 hours a day).

# Voices *of* Experience




Very early in my fire service career, my crew and I were dispatched late one evening to investigate the smell of ammonia at a small industrial plant. Upon our arrival at the plant's enclosed loading dock, I could immediately feel the ammonia in my eyes. The chief was already talking to the security staff when we joined the other crews at the loading dock. There was nothing visible that could have caused this incredibly strong smell of ammonia—there were no containers, vehicles, or equipment. In fact, the whole dock was wet—as if it had been hosed down at the end of the last shift.

Each crew was assigned areas of the facility to search for the source of the ammonia smell. As we searched, the smell sometimes became fainter, but it was always present, and there was no sign of any container or spill anywhere in the facility. We reassembled on the weathered, pitted concrete loading dock, still wet from its apparent cleaning. That's when it occurred to me to check the floor.

*"As we searched, the smell sometimes became fainter, but it was always present, and there was no sign of any container or spill anywhere in the facility."*

I reached down and touched the wet concrete with my glove and brought it up to my face. I immediately recognized the smell of ammonia and nearly fell over. My partner urged me to tell the chief that I had found the source of the ammonia, but I couldn't speak and I was having trouble keeping my balance. So, in my place, my partner told the chief what I had discovered: a powerful, ammonia-based cleaning product had been used to wash down the concrete floors. I remember receiving a nod of appreciation and a pat on the shoulder, but what I really deserved was a stern lecture about proper procedures for handling hazardous materials. If we had been dealing with a chemical more dangerous than ammonia, I could have died on the spot.

I learned two things about hazardous materials that night: Don't overlook the obvious, and don't take reckless chances. When I suspected that the ammonia smell was coming from the floor, my first step should have been to notify the chief or another fire fighter with training in identifying and handling hazardous materials. Only a trained specialist wearing the appropriate protective gear should conduct tests to confirm the presence or absence of a hazardous material.

Peter Sells
Toronto Fire Services
Toronto, Ontario

**Responder Tips**

Standard operating procedures, the emergency response plan, and the *ERG* will help you to identify the various protective actions and notifications that must be made for the types of responses anticipated within the jurisdiction. Standard operating procedures should define points of contact for local, state, and federal resources that might be called upon for assistance during hazardous materials emergencies.

The Mexican equivalent of CHEMTREC and CANUTEC is the Emergency Transportation System for the Chemical Industry, Mexico (SETIQ). SETIQ may be called (24 hours a day) at 01-800-00-214-00 in the Mexican Republic. For calls originating in Mexico City and its metropolitan area, call 5559-1588. For calls originating elsewhere, call +52-55-5559-1588.

Phone numbers for all of these agencies can be found in the *ERG*.

### National Response Center

Whenever a significant hazardous materials incident occurs, the National Response Center (NRC) must be notified. The NRC is operated by the U.S. Coast Guard and serves as a central notification point, rather than a guidance center. Once the NRC is notified, it will alert the appropriate state and federal agencies. The NRC must be notified if any spilled hazard discharges into the environment. The toll-free number for the NRC is 1-800-424-8802.

The NRC has established complex reporting requirements for different chemicals based on the reportable quantity (RQ) for that chemical. The shipper or the owner of the chemical has the ultimate legal responsibility to make this call, but by doing so themselves response agencies will have their reporting bases covered.

## Potential Terrorist Incidents

The threat of terrorism has changed the way public safety agencies operate. In small towns and major metropolitan areas, the possibility exists that on any day, a particular agency could find itself in the eye of a storm involving intentionally released chemical substances, biological agents (disease-causing bacteria or other viruses that attack the human body), or an attack on buildings or people using explosives. No area of any country is immune to such attacks. In this day and age, responders must recognize that they are a part of a much larger response mechanism in the United States; they must also understand that any incident involving terrorism will require the assistance and cooperation of countless local, state, and federal resources. Responders within every jurisdiction should be familiar with the locations of potential targets for terrorists; the general and specific hazards posed by chemical, biological, and radiological agents (materials that emit radioactivity); possible indicators of illicit laboratories; and basic operational guidelines for dealing with explosive events and identifying the possible indicators of secondary devices.

Potential targets for terrorist activities include both natural landmarks and human-made structures. These sites can be classified into three broad categories: infrastructure targets, symbolic targets, and civilian targets. The following sections will help you build a foundation to become a more informed responder when it comes to dealing with potential terrorist incidents.

### Chemical Agents

Indicators of possible criminal or terrorist activity involving chemical agents may vary depending on the complexity of the operation. Protective equipment such as rubber gloves, chemical suits, and respirators and chemical containers made of various materials, shapes, and sizes may be present. For example, glass containers are very prevalent at such incidents. The chemicals may provide unexplained odors that are out of character for the surroundings. Residual chemicals (liquid, powder, or gas form) may also be found in the area. Chemistry books or other reference materials may be seen, as well as materials that are used to manufacture chemical weapons (such as scales, thermometers, or torches). Chemical incidents also usually have some type of easily identifiable signature such as an odor, liquid or solid residue, or dead insects or foliage.

Personnel working around the materials may exhibit symptoms of chemical exposure—for example, irritation to the eyes, nose, and throat; difficulty breathing; tightness in the chest; nausea and vomiting; dizziness; headache; blurred vision; blisters or rashes; disorientation; or even convulsions. Chemical incidents are typically characterized by a rapid onset

Figure 3-38 White I label.

Figure 3-39 Yellow II label.

Figure 3-40 Yellow III label.

of symptoms (usually minutes to hours after exposure to the chemical agent).

## Biological Agents

Indicators of incidents that may potentially involve biological agents are similar to those that involve chemical agents. Production equipment such as Petri dishes, vented hoods, Bunsen burners, pipettes, microscopes, and incubators may be seen. Reference manuals such as microbiology or biology textbooks may be present. Containers used to transport biological agents may include metal cylindrical cans or red plastic boxes or bags with biological hazard labels. Personal protective equipment, including respirators, chemical or biological suits, and latex gloves, may be on the scene, as well as excessive amounts of antibiotics as a means to protect those working with the agents. Other potential indicators may include abandoned spray devices and unscheduled or unusual sprays being disseminated (especially if outdoors at night).

Personnel working in the area of the lab may exhibit symptoms consistent with the biological weapons with which they are working. Biological agents have a delayed onset of symptoms (usually days to weeks after the initial exposure). In fact, the biggest difference between a chemical incident and a biological incident is typically the speed of onset of the health effects from the involved agents. Because most biological agents are odorless and colorless, there are usually no outward indicators that the agents have spread.

## Radiological Agents

Indicators of radiological agents typically include production or containment equipment, such as lead or stainless steel containers (with nuclear or radiological labels), and equipment that may be used to detonate the radioactive source, such as containers (e.g., pipes), caps, fuses, gunpowder, timers, wire, and detonators. Personal protective equipment present may include radiological protective suits and respirators. Radiation monitoring equipment such as Geiger counters or radiation pagers may be present. Personnel working around the radiological agents may exhibit exposure symptoms such as burns or experience difficulty breathing.

When radiological agents are shipped, the package *type* is dictated by the degree of radiation activity inside the package—that is, the labeling is driven by the *amount of radiation that can be measured outside the package*. Three varieties of labels are found on radioactive packages: White I Figure 3-38, Yellow II Figure 3-39, and Yellow III Figure 3-40.

Additionally, shippers of radiological materials are required to include a transport index (TI) number on the package label. This number indicates the highest amount of radiation that can be measured 1 meter away from the surface of the package.

Responders must be able to recognize the potential situations where radioactive materials might be encountered. Industries that routinely use radioactive materials include food testing labs, hospitals, medical research centers, biotechnology facilities, construction sites, and medical laboratories. For the most part, there will be some visual indicators (signs or placards) that indicate the presence of radioactive substances, but this is not always the case.

The key is to be able to suspect, recognize, and understand when and where you may encounter radioactive sources. If you suspect a radiation incident at a fixed facility, you should initially consult with the radiation safety officer of the facility. This person is responsible for the use, handling, and storage procedures for all radioactive material at the site. He or she likely will be a tremendous resource to you and will know ex-

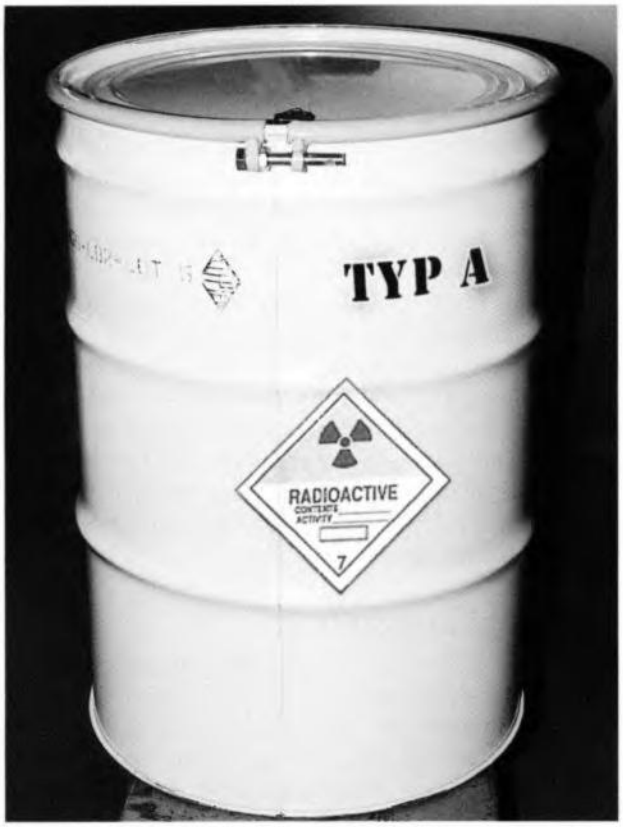



Figure 3-41 Type A package.

Figure 3-42 Type B package.

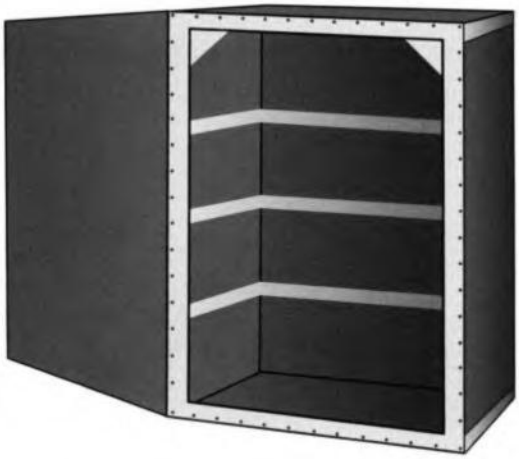


Figure 3-43 Type C package.

actly what is being used at the facility. If the incident is not at a fixed site, the presence of radiation may never be apparent. Radioactive isotopes are not detected by sight, smell, taste, or any of the other senses. Therefore, if you have any suspicion that the incident involves radiation, it will be necessary to call a hazardous materials team or some other resource with radiation detection capabilities.

Significant incidents involving radiation are rare, largely due to the comprehensiveness of the regulations for using, storing, and transporting significant radioactive sources. This is not to say that these incidents will not happen; nevertheless, the regulations have helped considerably in keeping the number of incidents low. Most of the incidents you may encounter will involve low-level radioactive sources and can be handled safely. These low-level sources are typically found in Type A packaging. This packaging method is unique to radioactive substances and contains materials such as radiopharmaceuticals and other low-level emitters.

### Radiological Packaging

The most common types of containers and packages used to store radioactive materials are divided into five major categories: excepted range radioactive packaging, industrial radioactive packaging, and Type A Figure 3-41 ▲, Type B Figure 3-42 ▸, and Type C Figure 3-43 ▸ packaging.

Type A packaging is designed to protect the internal radiological contents during normal transportation and in the event of a minor accident. Such packaging is characterized by having an inner containment vessel made of glass, plastic, or metal and external packaging materials made of polyethylene, rubber, or vermiculite.

Type B packaging is far more durable than Type A packaging and is designed to prevent a release in the case of extreme accidents during transportation. More dangerous radioactive sources might be found in Type B packaging. Some of the tests that Type B containers must undergo include heavy fire, pressure from submersion, and falls onto spikes and rocky surfaces. Type B packages include small drums and heavily shielded casks weighing more than 100 metric tons. This type of containment vessel contains materials such as spent radioactive waste and other high-level emitters. Type B packages are designed to protect their contents from greater exposure; the amount of protection is based on the potential severity of the hazard.

Figure 3-44 Items typically found at clandestine drug laboratories are everyday items.

Type C packaging is used when radioactive substances must be transported by air. Dangerous radioactive sources are shipped in Type C packaging.

Excepted packaging is packaging used to transport materials that meets only general design requirements for any hazardous material. Low-level radioactive substances are commonly shipped in excepted packages, which may be constructed out of heavy cardboard.

Industrial packaging is used to transport materials that present a limited hazard to the public or the environment. Contaminated equipment would be an example of such materials, as it contains a non-life-endangering amount of radioactivity. Industrial packaging is classified into three categories, based on the strength of the packaging.

## Illicit Laboratories

Many indicators of possible criminal or terrorist activity involving illicit laboratories may be evident to responders. For example, terrorist paraphernalia may include terrorist training manuals, ideological propaganda, and documents indicating affiliation with known terrorist groups. Locations with certain characteristics are also commonly sites of illicit (clandestine) laboratories—for example, basements with unusual or multiple vents, buildings with heavy security, buildings with obscured windows, and buildings with odd or unusual odors. Personnel working in illegal laboratory settings will exhibit a certain degree of suspicion. For instance, they may be nervous and have a high level of anxiety. In addition, they may be very protective of the laboratory area and not want to allow anyone to access the area for any reason, or they may rush people out of the area as soon as possible.

Equipment that may be present in illicit laboratory areas includes surveillance materials (such as videotapes, photographs, maps, blueprints, or time logs of the target hazard locations), nonweapon supplies (such as identification badges, uniforms, and decals that would be used to allow the terrorist to access target hazards), and weapons-related supplies (such as timers, switches, fuses, containers, wires, projectiles, and gunpowder or fuel). Security weapons such as guns, knives, and booby trap systems may be also present.

Drug laboratories are by far the most common type of clandestine laboratories encountered by responders. These laboratories are typically very primitive. Materials used to manufacture the drugs often consist of everyday items (jars, bottles, glass cookware, coolers, and tubing) that have been modified to produce the illicit drugs Figure 3-44.

Specific chemicals and materials found at the scene may include large quantities of cold tablets (ephedrine or pseudoephedrine), hydrochloric or sulfuric acid, paint thinner, drain cleaners, iodine crystals, table salt, aluminum foil, and camera batteries. The strong smell of urine or unusual chemical smells such as ether, ammonia, or acetone are very common indicators of clandestine drug manufacturing. Illicit drug laboratories should be considered significant hazardous materials scenes, because the inexperienced chemists who run them take many shortcuts and disregard typical safety protocols so as to increase production.

## Explosives

Indicators of possible criminal or terrorist activity involving explosives typically include materials that fit into four major categories—protective equipment, production and containment materials, explosive materials, and support materials. Protective equipment may include rubber gloves, goggles and face shields, and fire extinguishers. Production and containment equipment may include funnels, spoons, threaded pipes, caps, fuses, timers, wires, detonators, and concealment containers such as briefcases, backpacks, or other common packages. Explosive materials may include gunpowder, gasoline, fertilizer, and similar materials. Support materials may include explosive reference manuals, Internet-based reference materials, and military information.

## Secondary Devices

By definition, a secondary device is some form of explosive or incendiary device designed to harm those responders summoned to scene for some other reason. Terrorists who want to injure responding personnel with a secondary device or attack will typically make the initial attack very dramatic so as to draw responders into close proximity of the scene. The secondary attack usually takes place as the responders begin to treat victims of the initial attack.

Indicators of potential secondary devices may include "trip devices" such as timers, wires, or switches. Common concealment containers, such as briefcases, backpacks, boxes, or other common packages, may also be present; uncommon concealment containers may include pressure vessels (propane tanks) or industrial chemical containers (chlorine storage containers). Personnel may watch the site of the primary devices, as part of preparing to manually activate the secondary devices.

# Wrap-Up

## Chief Concepts

- Responders must interpret visual clues effectively to improve their ability to mitigate an incident.
- Responders should be able to recognize the various container profiles and understand the general classifications of materials that may be stored inside each type of container.
- Responders should be able to name, understand, and locate the various types of shipping papers on various modes of transportation.
- Roadway vehicles often transport shipments from the rail station, airport, or dock to the point where the materials will ultimately be used. For this reason, responders must become familiar with all types of chemical transport vehicles.
- When used correctly, various marking systems indicate the presence of a hazardous material and provide clues about the substance. The DOT, NFPA, HMIS, and the military have all developed marking systems specific to their level of response.
- Responders should be able to demonstrate proficiency when using the *Emergency Response Guidebook*.
- Responders should know how to obtain MSDS documentation from various sources, including their own department, the scene of the incident itself, or the manufacturer of the material.
- Responders should become familiar with the locations of potential terrorist targets in their jurisdiction; the general and specific hazards of chemical, biological, and radiological agents; indicators of illicit laboratories; and basic operational guidelines for dealing with explosive events and identifying the possible indicators of secondary devices.

## Hot Terms

Above-ground storage tank (AST) A tank that can hold anywhere from a few hundred gallons to several million gallons of product. ASTs are usually made of aluminum, steel, or plastic.

Air bill The shipping papers on an airplane.

Bill of lading The shipping papers used for transport of chemicals over roads and highways. Also referred to as a freight bill.

Biological agents Disease-causing bacteria, viruses, and other agents that attack the human body.

Bulk storage container A large-volume container that has an internal volume greater than 119 gallons for liquids and a capacity greater than 882 pounds for solids and greater than 882 pounds for gases.

Bung A small opening in a closed-head drum.

Canadian Transport Emergency Centre (CANUTEC) A national call center located in Ottawa, Canada. This organization serves Canadian responders (in French and English) in much the same way CHEMTREC serves responders in the United States.

Carboy A glass, plastic, or steel nonbulk storage container, ranging in volume from 5 to 15 gallons.

Cargo tank Bulk packaging that is permanently attached to or forms a part of a motor vehicle, or is not permanently attached to any motor vehicle, and that, because of its size, construction, or attachment to a motor vehicle, is loaded or unloaded without being removed from the motor vehicle.

Chemical Transportation Emergency Center (CHEMTREC) A U.S. national call center that provides basic chemical information. It is operated by the American Chemistry Council.

Consist A list of the contents of every car on a train.

Container Any vessel or receptacle that holds material, including storage vessels, pipelines, and packaging.

Cryogenic liquid (cryogen) A gaseous substance that has been chilled to the point where it has liquefied; a liquid having a boiling point lower than –150°F (–101°C) at 14.7 psi (an absolute pressure of 101 kPa).

Cylinder A portable, nonbulk, compressed gas container used to hold liquids and gases. Uninsulated compressed gas cylinders are used to store substances such as nitrogen, argon, helium, and oxygen. They have a range of sizes and internal pressures.

Dangerous cargo manifest The shipping papers on a marine vessel, generally located in a tube-like container.

Department of Transportation (DOT) marking system A unique system of labels and placards that is used when materials are being transported from one location to another in the United States. The same marking system is used in Canada by Transport Canada.

Dewar container A container designed to preserve the temperature of the cold liquid held inside.

Drum A barrel-like nonbulk storage vessel used to store a wide variety of substances, including food-grade materials, corrosives, flammable liquids, and grease.

Drums may be constructed of low-carbon steel, polyethylene, cardboard, stainless steel, nickel, or other materials.

Dry bulk cargo tank A tank designed to carry dry bulk goods such as powders, pellets, fertilizers, or grain. Such tanks are generally V-shaped with rounded sides that funnel toward the bottom.

*Emergency Response Guidebook (ERG)* A preliminary action guide for first responders operating at a hazardous materials incident in coordination with the U.S. Department of Transportation's (DOT) labels and placards marking system. The DOT and the Secretariat of Communications and Transportation of Mexico (SCT), along with Transport Canada, jointly developed the *Emergency Response Guidebook*.

Emergency Transportation System for the Chemical Industry, Mexico (SETIQ) A national response center that is the Mexican equivalent of CHEMTREC and CANUTEC.

Excepted packaging Packaging used to transport materials that meets only general design requirements for any hazardous material. Low-level radioactive substances are commonly shipped in excepted packages, which may be constructed out of heavy cardboard.

Freight bill The shipping papers used for transport of chemicals along roads and highways. Also referred to as a bill of lading.

Hazardous material Any substance or material that is capable of posing an unreasonable risk to human health, safety, or the environment when transported in commerce, used incorrectly, or not properly contained or stored.

Hazardous Materials Information System (HMIS) A color-coded marking system by which employers give their personnel the necessary information to work safely around chemicals. The Workplace Hazardous Materials Information System (WHMIS) is the Canadian hazard communication standard.

Industrial packaging Packaging used to transport materials that present a limited hazard to the public or the environment. Contaminated equipment is an example of such material, as it contains a non-life-endangering amount of radioactivity. Industrial packaging is classified into three categories, based on the strength of the packaging.

Intermodal tank A bulk container that serves as both a shipping and storage vessel. Such tanks hold between 5000 gallons and 6000 gallons of product and can be either pressurized or nonpressurized. Intermodal tanks can be shipped by all modes of transportation—air, sea, or land.

Label A smaller version (4-inch diamond-shaped markings) of a placard. Labels are placed on all four sides of individual boxes and smaller packages that are being transported.

Material safety data sheet (MSDS) A form, provided by manufacturers and compounders (blenders) of chemicals, containing information about chemical composition, physical and chemical properties, health and safety hazards, emergency response, and waste disposal of a specific material.

MC-306/DOT 406 flammable liquid tanker Such a vehicle typically carries between 6000 gallons and 10,000 gallons of a product such as gasoline or other flammable and combustible materials. The tank is nonpressurized.

MC-307/DOT 407 chemical hauler A tanker with a rounded or horseshoe-shaped tank capable of holding 6000 to 7000 gallons of flammable liquid, mild corrosives, and poisons. The tank has a high internal working pressure.

MC-312/DOT 412 corrosive tanker A tanker that often carries aggressive (highly reactive) acids such as concentrated sulfuric and nitric acid. It is characterized by several heavy-duty reinforcing rings around the tank and holds approximately 6000 gallons of product.

MC-331 pressure cargo tanker A tanker that carries materials such as ammonia, propane, Freon, and butane. This type of tank is commonly constructed of steel and has rounded ends and a single open compartment inside. The liquid volume inside the tank varies, ranging from the 1000-gallon delivery truck to the full-size 11,000-gallon cargo tank.

MC-338 cryogenic tanker A low-pressure tanker designed to maintain the low temperature required by the cryogens it carries. A boxlike structure containing the tank control valves is typically attached to the rear of the tanker.

National Response Center (NRC) An agency maintained and staffed by the U.S. Coast Guard; it should always be notified if a hazard discharges into the environment.

NFPA 704 hazard identification system A hazardous materials marking system designed for fixed-facility use. It uses a diamond-shaped symbol of any size,

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which is itself broken into four smaller diamonds, each representing a particular property or characteristic of the material.

Nonbulk storage vessel Any container other than bulk storage containers such as drums, bags, compressed gas cylinders, and cryogenic containers. Nonbulk storage vessels hold commonly used commercial and industrial chemicals such as solvents, industrial cleaners, and compounds.

Nonpressurized (general-service) rail tank car A railcar equipped with a tank that typically holds general industrial chemicals and consumer products such as corn syrup, flammable and combustible liquids, and mild corrosives.

Pipeline A length of pipe—including pumps, valves, flanges, control devices, strainers, and/or similar equipment—for conveying fluids and gases.

Pipeline right-of-way An area, patch, or roadway that extends a certain number of feet on either side of a pipeline and that may contain warning and informational signs about hazardous materials carried in the pipeline.

Placard Signage required to be placed on all four sides of highway transport vehicles, railroad tank cars, and other forms of hazardous materials transportation; the sign identifies the hazardous contents of the vehicle, using a standardization system with 10¾-inch diamond-shaped indicators.

Pressurized rail tank car A railcar used to transport materials such as propane, ammonia, ethylene oxide, and chlorine.

Radiological agents Materials that emit radioactivity (the spontaneous decay or disintegration of an unstable atomic nucleus accompanied by the emission of radiation).

Secondary containment Any device or structure that prevents environmental contamination when the primary container or its appurtenances fail. Examples of secondary containment mechanisms include dikes, curbing, and double-walled tanks.

Secondary device An explosive or incendiary device designed to harm emergency responders who have responded to an initial event.

Shipping papers A shipping order, bill of lading, manifest, or other shipping document serving a similar purpose; it usually includes the names and addresses of both the shipper and the receiver as well as a list of the shipped materials along with their quantity and weight.

Signal words Information on a pesticide label that indicates the relative toxicity of the material.

Special-use railcar A boxcar, flat car, cryogenic tank car, or corrosive tank car.

Tote A portable tank, also referred to as an intermediate bulk container (IBC), that has a capacity in the range of 119 gallons to 703 gallons. It is characterized by a unique style of construction.

Toxic inhalation hazard (TIH) Any gas or volatile liquid that is extremely toxic to humans.

Tube trailer A high-volume transportation device made up of several individual compressed gas cylinders banded together and affixed to a trailer. Tube trailers carry compressed gases such as hydrogen, oxygen, helium, and methane. One trailer may carry several different gases in individual tubes.

Type A packaging Packaging that is designed to protect its internal radiological contents during normal transportation and in the event of a minor accident.

Type B packaging Packaging that is far more durable than Type A packaging and is designed to prevent a release of the radiological hazard in the case of extreme accidents during transportation. Type B containers must undergo a battery of tests including those involving heavy fire, pressure from submersion, and falls onto spikes and rocky surfaces.

Type C packaging Packaging used when radioactive substances must be transported by air.

Underground storage tank (UST) A type of tank that can hold anywhere from a few hundred gallons to several million gallons of product. USTs are usually made of aluminum, steel, or plastic.

Vent pipes Inverted J-shaped tubes that allow for pressure relief or natural venting of the pipeline for maintenance and repairs.

Waybill Shipping papers for railroad transport.

# Responder *in Action*

It is a rainy afternoon when your engine company is dispatched to a motor vehicle accident. Upon arrival, you see a large tractor-trailer rig on its side, with a single tank compartment that has rounded ends. The tank is painted white and appears to be a pressurized vessel.

1. Which type of container is this likely to be?
   - **A.** MC-306/DOT 406
   - **B.** MC-307/DOT 407
   - **C.** MV-312
   - **D.** MC-331
2. Which documents should be found in the cab of the vehicle?
   - **A.** Bill of lading
   - **B.** Waybill
   - **C.** Dangerous cargo manifest
   - **D.** Consists
3. Which section of the *Emergency Response Guidebook* (*ERG*) includes the name of the chemical first and then the guide number and ID number?
   - **A.** Green section
   - **B.** Orange section
   - **C.** Yellow section
   - **D.** Blue section
4. In which section of the *Emergency Response Guidebook* should you look when you can identify a UN/ID number?
   - **A.** Green section
   - **B.** Orange section
   - **C.** Yellow section
   - **D.** Blue section

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CHAPTER

# 4

## NFPA 472 Standard

### Competencies for Awareness Level Personnel

**4.4.1 Initiating Protective Actions.** Given examples of hazardous materials/WMD incidents, the emergency response plan, the standard operating procedures, and the current edition of the DOT *Emergency Response Guidebook*, awareness level personnel shall be able to identify the actions to be taken to protect themselves and others and to control access to the scene and shall meet the following requirements:

(1) Identify the location of both the emergency response plan and/or standard operating procedures.

(2) Identify the role of the awareness level personnel during hazardous materials/WMD incidents.

(3) Identify the following basic precautions to be taken to protect themselves and others in hazardous materials/WMD incidents:

(a) Identify the precautions necessary when providing emergency medical care to victims of hazardous materials/WMD incidents.

(b) Identify typical ignition sources found at the scene of hazardous materials/WMD incidents.

(c) Identify the ways hazardous materials/WMD are harmful to people, the environment, and property.

(d) Identify the general routes of entry for human exposure to hazardous materials/WMD.

(4) Given examples of hazardous materials/WMD and the identity of each hazardous material/WMD (name, UN/NA identification number, or type placard), identify the following response information:

(a) Emergency action (fire, spill, or leak and first aid)

(b) Personal protective equipment necessary

(c) Initial isolation and protective action distances

(5) Given the name of a hazardous material, identify the recommended personal protective equipment from the following list:

(a) Street clothing and work uniforms [p. 94]

(b) Structural fire-fighting protective clothing [p. 94]

(c) Positive pressure self-contained breathing apparatus [p. 99–100]

(d) Chemical-protective clothing and equipment [p. 95–98]

(6) Identify the definitions for each of the following protective actions:

(a) Isolation of the hazard area and denial of entry [p. 88]

(b) Evacuation [p. 88]

(c) Sheltering in-place [p. 88]

(7) Identify the size and shape of recommended initial isolation and protective action zones. [p. 86–88]

(8) Describe the difference between small and large spills as found in the Table of Initial Isolation and Protective Action Distances in the DOT *Emergency Response Guidebook*. [p. 86–88]

(9) Identify the circumstances under which the following distances are used at a hazardous materials/WMD incidents:

(a) Table of Initial Isolation and Protective Action Distances [p. 86–88]

(b) Isolation distances in the numbered guides [p. 86–88]

(10) Describe the difference between the isolation distances on the orange-bordered guidebook pages and the protective action distances on the green-bordered ERG (*Emergency Response Guidebook*) pages. [p. 88]

(11) Identify the techniques used to isolate the hazard area and deny entry to unauthorized persons at hazardous materials/WMD incidents. [p. 88]

(12) Identify at least four specific actions necessary when an incident is suspected to involve criminal or terrorist activity. [p. 91–92]

### Core Competencies for Operations Level Responders

**5.1.2 Goal.**

**5.1.2.1** The goal of the competencies at this level shall be to provide operations level responders with the knowledge and skills to perform the core competencies in 5.1.2.2 safely. [p. 84–102]

**5.1.2.2** When responding to hazardous materials/WMD incidents, operations level responders shall be able to perform the following tasks:

(1) Analyze a hazardous materials/WMD incident to determine the scope of the problem and potential outcomes by completing the following tasks:

(a) Survey a hazardous materials/WMD incident to identify the containers and materials involved, determine whether hazardous materials/WMD have been released, and evaluate the surrounding conditions. [p. 84–92]

(b) Collect hazard and response information from MSDS; CHEMTREC/CANUTEC/SETIQ; local, state, and federal authorities; and shipper/manufacturer contacts. [p. 84–92]

(c) Predict the likely behavior of a hazardous material/WMD and its container. [p. 86–88]

(d) Estimate the potential harm at a hazardous materials/WMD incident. [p. 84–90]

(2) Plan an initial response to a hazardous materials/WMD incident within the capabilities and competencies of available personnel and personal protective equipment by completing the following tasks:

(a) Describe the response objectives for the hazardous materials/WMD incident. [p. 90–92]

(b) Describe the response options available for each objective. [p. 90–92]

(c) Determine whether the personal protective equipment provided is appropriate for implementing each option. [p. 92–94]

(d) Describe emergency decontamination procedures. [p. 101–102]

(e) Develop a plan of action, including safety considerations. [p. 90–92]

(3) Implement the planned response for a hazardous materials/WMD incident to favorably change the outcomes consistent with the emergency response plan and/or standard operating procedures by completing the following tasks:

(a) Establish and enforce scene control procedures, including control zones, emergency decontamination, and communications.

(b) Where criminal or terrorist acts are suspected, establish means of evidence preservation.

(c) Initiate an incident command system (ICS) for hazardous materials/WMD incidents.

(d) Perform tasks assigned as identified in the incident action plan.

(e) Demonstrate emergency decontamination.

(4) Evaluate the progress of the actions taken at a hazardous materials/WMD incident to ensure that the response objectives are being met safely, effectively, and efficiently by completing the following tasks:

(a) Evaluate the status of the actions taken in accomplishing the response objectives.

(b) Communicate the status of the planned response.

**5.2.4 Estimating Potential Harm.** Given scenarios involving hazardous materials/WMD incidents, the operations level responder shall estimate the potential harm within the endangered area at each incident and shall meet the following requirements:

(1) Identify a resource for determining the size of an endangered area of a hazardous materials/WMD incident. [p. 86–88]

(2) Given the dimensions of the endangered area and the surrounding conditions at a hazardous materials/WMD incident, estimate the number and type of exposures within that endangered area. [p. 88–90]

(3) Identify resources available for determining the concentrations of a released hazardous material/WMD within an endangered area. [p. 89–90]

(4) Given the concentrations of the released material, identify the factors for determining the extent of physical, health, and safety hazards within the endangered area of a hazardous materials/WMD incident. [p. 84–92]

(5) Describe the impact that time, distance, and shielding have on exposure to radioactive materials specific to the expected dose rate. [p. 86]

**5.3 Core Competencies—Planning the Response.**

**5.3.1 Describing Response Objectives.** Given at least two scenarios involving hazardous materials/WMD incidents, the operations level responder shall describe the response objectives for each example and shall meet the following requirements:

(1) Given an analysis of a hazardous materials/WMD incident and the exposures, determine the number of exposures that could be saved with the resources provided by the AHJ. [p. 84–90]

(2) Given an analysis of a hazardous materials/WMD incident, describe the steps for determining response objectives. [p. 90–92]

(3) Describe how to assess the risk to a responder for each hazard class in rescuing injured persons at a hazardous materials/WMD incident. [p. 90–91]

(4) Assess the potential for secondary attacks and devices at criminal or terrorist events. [p. 91–92]

**5.3.2 Identifying Action Options.** Given examples of hazardous materials/WMD incidents (facility and transportation), the operations level responder shall identify the options for each response objective and shall meet the following requirements:

(1) Identify the options to accomplish a given response objective. [p. 91]

(2) Describe the prioritization of emergency medical care and removal of victims from the hazard area relative to exposure and contamination concerns. [p. 84–86]

**5.3.3 Determining Suitability of Personal Protective Equipment.** Given examples of hazardous materials/WMD incidents, including the name of the hazardous material/WMD involved and the anticipated type of exposure, the operations level responder shall determine whether available personal protective equipment is applicable to performing assigned tasks and shall meet the following requirements:

(1) Identify the respiratory protection required for a given response option and the following:

(a) Describe the advantages, limitations, uses, and operational components of the following types of respiratory protection at hazardous materials/WMD incidents:

i. Positive pressure self-contained breathing apparatus (SCBA) [p. 99–100]

ii. Positive pressure air-line respirator with required escape unit [p. 100]

iii. Closed-circuit SCBA [p. 100]

iv. Powered air-purifying respirator (PAPR) [p. 101]

v. Air-purifying respirator (APR) [p. 100–101]

vi. Particulate respirator [p. 100–101]

(b) Identify the required physical capabilities and limitations of personnel working in respiratory protection. [p. 99]

(2) Identify the personal protective clothing required for a given option and the following:

(a) Identify skin contact hazards encountered at hazardous materials/WMD incidents. [p. 90]

(b) Identify the purpose, advantages, and limitations of the following types of protective clothing at hazardous materials/WMD incidents:

i. Chemical-protective clothing: liquid splash–protective clothing and vapor-protective clothing [p. 95–96]

ii. High temperature–protective clothing: proximity suit and entry suits [p. 94–95]

iii. Structural fire-fighting protective clothing [p. 94]

**5.3.4 Identifying Decontamination Issues.** Given scenarios involving hazardous materials/WMD incidents, operations level responders shall identify when emergency decontamination is needed and shall meet the following requirements:

(1) Identify ways that people, personal protective equipment, apparatus, tools, and equipment become contaminated. [p. 101–102]

(2) Describe how the potential for secondary contamination determines the need for decontamination. [p. 102]

(3) Explain the importance and limitations of decontamination procedures at hazardous materials incidents. [p. 101–102]

(4) Identify the purpose of emergency decontamination procedures at hazardous materials incidents. [p. 101–102]

(5) Identify the factors that should be considered in emergency decontamination. [p. 101–102]

(6) Identify the advantages and limitations of emergency decontamination procedures. [p. 101–102]

**5.4.4 Using Personal Protective Equipment.** The operations level responder shall describe considerations for the use of personal protective equipment provided by the AHJ, and shall meet the following requirements:

(1) Identify the importance of the buddy system.

(2) Identify the importance of the backup personnel.

(3) Identify the safety precautions to be observed when approaching and working at hazardous materials/WMD incidents.

(4) Identify the signs and symptoms of heat and cold stress and procedures for their control.

(5) Identify the capabilities and limitations of personnel working in the personal protective equipment provided by the AHJ.

(6) Identify the procedures for cleaning, disinfecting, and inspecting personal protective equipment provided by the AHJ. [p. 92–94]

(7) Describe the maintenance, testing, inspection, and storage procedures for personal protective equipment provided by the AHJ according to the manufacturer's specifications and recommendations. [p. 92–94]

## Knowledge Objectives

After studying this chapter, you will be able to:

- Describe how to estimate the potential harm or the severity of a hazardous materials/weapons of mass destruction (WMD) incident.
- Describe resources to determine the size of a hazardous materials/WMD incident.
- Describe exposure protection.
- Describe how to report the size and scope of an incident.
- Describe resources available for determining the concentrations of a released hazardous material.
- Identify skin-contact hazards encountered at hazardous materials/WMD incidents.
- Describe how to plan an initial response.
- Describe the potential for secondary attacks/devices.
- Describe personal protective equipment (PPE) used for hazardous materials/WMD incidents and how to care for it.
- Identify the purpose, advantages, and limitations of the following items:
  - Street clothing and work uniforms
  - Structural firefighting protective clothing
  - High-temperature–protective clothing and equipment
  - Chemical-protective clothing and equipment
- Discuss the levels of hazardous materials/WMD personal protective equipment (PPE).
- Discuss the importance of respiratory protection in a hazardous materials/WMD incident.
- Describe the physical capabilities required and limitations of personnel working in PPE.
- Describe the importance of having a plan in place to decontaminate a victim.

## Skills Objectives

There are no skills objectives for this chapter.

## You Are the Responder

Your rescue ambulance has been called to a semiconductor fabrication facility for a report of shortness of breath. You arrive at the reception area and are led to an employee break room. As you approach the seated patient, you notice a strong odor of ammonia. The laboratory manager is standing next to the patient—a laboratory technician—who is doubled over in the chair. The laboratory manager tells you that the technician was splashed in the face with approximately 100 mL of ammonium hydroxide while pouring chemicals into an instrument. He states that he helped the laboratory technician to an eye-wash station immediately after the incident and then escorted him to the break room. The laboratory manager tells you he has seen this sort of injury before. In his opinion, the laboratory technician doesn't need to go to the hospital—he just needs some oxygen. The paramedic begins an assessment and finds that the laboratory technician has reddened skin over his entire face and is complaining of shortness of breath.

1. What are your initial response priorities?
2. What are your initial objectives for the incident?
3. Are you at risk of being exposed or contaminated to potentially toxic levels of ammonium hydroxide from this patient?

## Introduction

It is important to have a set of basic response priorities to guide your decision making at the scene of a hazardous materials/WMD incident. To that end, the first response priority should be to ensure your own safety while operating at the scene. You're no good to anyone if you've become part of the problem! At a minimum, you must arrive at the scene in a safe manner and make sure that you and your crew do not become a liability during the course of the incident.

After ensuring your own safety, your next objective should be to address the potential life safety of those persons affected by the incident. In the scenario described in the chapter-opening vignette, your crew responded for one type of emergency—shortness of breath—and ended up facing a completely different kind of problem—a medical issue related to a chemical exposure. This new set of parameters will require you to quickly shift gears. You now have an exposed victim and a potentially exposed laboratory manager. Which additional response personnel and equipment will be required? You can smell the ammonia: Does that mean you and other personnel are in danger, too? Has the patient been adequately decontaminated to the point you can safely render care? Who performed the decontamination? What type of decontamination was done? Should you back out of the area without treating the victim and call for a hazardous materials/WMD response team?

Such real-world challenges involve a set of complicated questions. This chapter will help you to estimate and plan for the challenges you may encounter at a hazardous materials/WMD incident.

## Estimating the Potential Harm or Severity of the Incident

Hazardous materials/WMD incident response priorities should be based on the need to protect and/or reduce the threat to life, property, critical systems, and the environment. Remember—it is important to separate the people from the problem as soon as possible. In some cases, the people and the problem are one and the same, as in the chapter-opening scenario. Once the threat to life has been handled, the incident becomes a matter of reducing the impact to the property that may be affected and minimizing environmental complications.

The damage that a hazardous material/WMD will inflict on a human being is a function of the physical and chemical properties of the released substance, as well as the conditions under which it was released. Among other factors, characteristics such as the concentration of the material, the temperature of the material at the time of its release, and the pressure under which the substance was released will affect both the release parameters and the potential health effects on those exposed to the

material. Additionally, the age, gender, genetics, and underlying medical conditions of the exposed person will have some bearing on patient outcome. Chemical exposures are complicated events because of the number of variables that may be present.

When it comes to rendering medical care to persons exposed to harmful substances, guidance can be found in NFPA 473, *Standard for Competencies for EMS Personnel Responding to Hazardous Materials/Weapons of Mass Destruction Incidents*. This standard was revised along with the 2008 version of NFPA 472, *Standard for Competence of Responders to Hazardous Materials/Weapons of Mass Destruction Incidents*, and centers on the notion that all EMS responders, regardless of their scope of practice, should share a basic set of hazardous materials response skills to work safely on a hazardous materials/WMD scene and deliver effective patient care. *In most cases, that care is performed in a safe area away from the hazard, after decontamination.* EMS responders, however, should understand the nature of the incident and look at the scene with a critical eye to pick up the clues that might assist with defining the nature of the exposure.

To have some frame of reference for the degree of harm a substance may inflict, responders should have a basic understanding of some commonly used terms and definitions. Two main organizations establish and publish the toxicological data typically used by hazardous materials/WMD responders: the American Conference of Governmental Industrial Hygienists (ACGIH) and the Occupational Safety and Health Administration (OSHA).

For more than 60 years, the ACGIH has been a respected and trusted source for occupational health and industrial hygiene guidelines and information. Its best-known committee, the Threshold Limit Values for Chemical Substances (TLV®-CS) Committee, was established in 1941. This committee first introduced the concept of threshold limit value (TLV) in 1956. The threshold limit value is the point at which a hazardous material/WMD begins to affect a person. Today, TLVs have been published for more than 600 chemical substances. Any values indicated with a TLV are established by the ACGIH.

OSHA was created in 1971 with three goals: to improve worker safety, to conduct research, and to publish toxicological data. OSHA's permissible exposure limit (PEL) for example, is conceptually the same as ACGIH's TLV term. The PEL is the established standard limit of exposure to a hazardous material. You might see both of these terms in a reference source, for example. Nevertheless, there is an important distinction between the ACGIH and OSHA standards: While ACGIH sets guidelines, OSHA standards are the law.

It is common to see toxicological values expressed in units of parts per million (ppm), parts per billion (ppb), and, in some cases, parts per trillion (ppt). Typically, the amount of airborne contamination encountered with releases of gases such as arsine, chlorine, and ammonia will be expressed in this manner. Arsine, for example, has an OSHA established PEL of 0.05 ppm. This is a very small amount compared to the OSHA PEL for chlorine, which is 1 ppm. Comparatively speaking, arsine is a far more toxic substance than chlorine.

Another way to express contamination levels for substances other than gases, such as fibers and dusts, is through units of milligram per cubic meter ($mg/m^3$). For the purpose of simplicity and better understanding of this section of the text, keep in mind that you may see toxicological data expressed in several different ways. In any event, the lower the value, the more toxic the product.

### Responder Tips

One part per million (ppm) means there is one particle of a given substance for 999,999 other particles. Think of it this way: 1 ppm equates to 1 second in 280 hours.

One part per billion is equivalent to one particle in 999,999,999 other particles. Thus 1 ppb equates to 1 second in 32 years.

One part per trillion (ppt) is equivalent to 1 second in 320 centuries.

The threshold limit value/short-term exposure limit (TLV/STEL) is the maximum concentration of a hazardous material that a person can be exposed to in 15-minute intervals, up to four times per day, without experiencing irritation or chronic or irreversible tissue damage. A minimum 1-hour rest period should separate any exposures to this concentration of the material. The lower the TLV/STEL concentration, the more toxic the substance. The threshold limit value/time-weighted average (TLV/TWA) is the maximum airborne concentration of material that a worker could be exposed to for 8 hours a day, 40 hours a week, with no ill effects. As with the TLV/STEL, the lower the TLV/TWA, the more toxic the substance. The threshold limit value/ceiling (TLV/C) is the maximum concentration of a hazardous material that a worker should not be exposed to, even for an instant. Again, the lower the TLV/C, the more toxic the substance.

The threshold limit value/skin indicates that direct or airborne contact with a material could result in possible and significant exposure from absorption through the skin, mucous membranes, and eyes. This designation is intended to suggest that appropriate measures be taken to minimize skin absorption so that the TLV/TWA is not exceeded.

As mentioned earlier, the permissible exposure limit (PEL) is the standard limit of exposure to a hazardous material as established by OSHA. The recommended exposure level (REL) is a value established by the National Institute for Occupational Safety and Health (NIOSH) and is comparable to OSHA's PEL. NIOSH is part of the U.S. Department of Health and Human Services and is charged with ensuring that individuals have a safe and healthy work environment by providing information, training, research, and education in the field of occupational safety and health. The PEL and REL limits are comparable to ACGIH's TLV/TWA. These three terms (PEL, REL, and TLV/TWA) measure the maximum, time-weighted concentration of material to which 95 percent of healthy adults can be exposed without suffering any adverse effects over a 40-hour workweek.

The designation immediately dangerous to life and health (IDLH) means that an atmospheric concentration of a

**Responder Safety Tips**

Identifying and measuring the levels of airborne contamination require specific detection and monitoring instruments along with training to interpret the results.

toxic, corrosive, or asphyxiant substance poses an immediate threat to life or could cause irreversible or delayed adverse health effects. Three types of IDLH atmospheres are distinguished: toxic, flammable, and oxygen deficient. Individuals exposed to atmospheric concentrations below the IDLH value (in theory) could escape from the atmosphere without experiencing irreversible damage to their health, even if their respiratory protection fails. Individuals who may be exposed to atmospheric concentrations equal to or higher than the IDLH value must use positive-pressure self-contained breathing apparatus (SCBA) or equivalent protection.

With the appropriate equipment, responders will be able to measure concentrations of specific chemicals.

Once these exposure values are understood, they can be applied at the scene of a hazardous materials/WMD emergency. For example, exposure guidelines can be used to define the three basic atmospheres that might be encountered at a hazardous materials/WMD emergency:

- Safe atmosphere: No harmful hazardous materials effects exist, so personnel can handle routine emergencies without donning specialized personal protective equipment (PPE).
- Unsafe atmosphere: A hazardous material that is no longer contained has created an unsafe condition or atmosphere. A person who is exposed to the material for long enough will probably experience some form of acute or chronic injury.
- Dangerous atmosphere: Serious, irreversible injury or death may occur in the environment.

**Responder Safety Tips**

Initial isolation zones and protective actions are valid only for a 30-minute window from the start of the release.

All exposure guidelines share a common goal: to ensure the safety and health of people exposed to a hazardous material.

## Resources for Determining the Size of the Incident

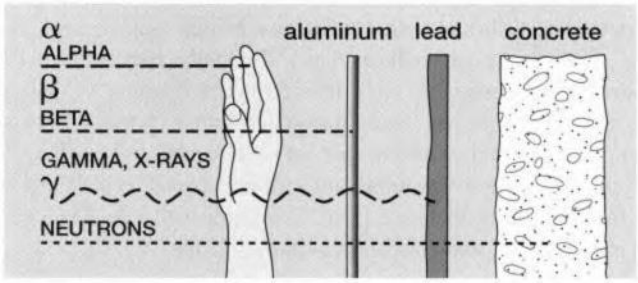
It is vital to understand the incident as a whole. To do so, responders must plug in results obtained from detection and monitoring devices, reference sources, bystander information, the prevailing environmental conditions surrounding the incident, and other information to get a clear picture of what is going on and what is likely to happen next. Sometimes a decision must be made to evacuate or rescue people in danger. In those instances, responders may need to consult printed and electronic reference sources for guidance on evacuation distances and other safety information. A number of computer programs can be used to model and predict the direction and size of vapor clouds. When used properly, these computer programs can be a valuable source of information for predicting the size, shape, and direction of movement of vapor clouds. Again, it is important to identify the health hazards posed by the substance to accurately set safe parameters around the entire incident.

A valuable resource to consult for evacuation distances is the *Emergency Response Guidebook* (*ERG*), which is updated every three or four years to address new substances and/or new technologies. This reference book identifies and outlines predetermined evacuation distances and basic action plans for chemicals, based on spill size estimates Figure 4-1 ›.

**Responder Safety Tips**

**Time–Distance–Shielding**

To reduce the effects of a radiation exposure, responders should understand the concept of time–distance–shielding (TDS). When a radiation source is suspected or confirmed, responders should take action to reduce the amount of time they are exposed to the source; remain as far away as necessary, and place some form of barrier between themselves and the source. Identifying the presence of a radioactive source may require using a radiation detector. In the event you do not have such a device, or if you have a reasonable suspicion that the incident may involve a radioactive source, employ basic tactics that utilize the concept of TDS. Think of TDS in this way: The less time you spend in the sun, the less chance you have of suffering a sunburn (*time*); the closer you stand to a fire, the hotter you will get (*distance*); and if you come inside during a rainstorm, you will stop getting wet (*shielding*). These basic illustrations are analogous to the TDS concept for reducing the health effects of a radiation exposure.



**HOW TO USE TABLE 1 - INITIAL ISOLATION AND PROTECTIVE ACTION DISTANCES**

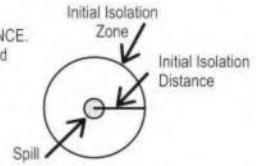
(1) The responder should already have:

- Identified the material by its ID Number and Name; (if an ID Number cannot be found, use the Name of Material index in the blue-bordered pages to locate that number.)
- Found the three-digit guide for that material in order to consult the emergency actions recommended jointly with this table;
- **Noted the wind direction.**

(2) Look in Table 1 (the green-bordered pages) for the ID Number and Name of the Material involved in the incident. Some ID Numbers have more than one shipping name listed—look for the specific name of the material. (If the shipping name is not known and Table 1 lists more than one name for the same ID Number, use the entry with the largest protective action distances.)

(3) Determine if the incident involves a SMALL or LARGE spill and if DAY or NIGHT. Generally, a SMALL SPILL is one which involves a single, small package (e.g., a drum containing up to approximately 200 liters), a small cylinder, or a small leak from a large package. A LARGE SPILL is one which involves a spill from a large package, or multiple spills from many small packages. DAY is any time after sunrise and before sunset. NIGHT is any time between sunset and sunrise.

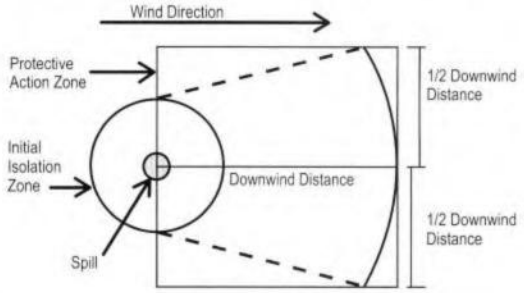
(4) Look up the INITIAL ISOLATION DISTANCE. Direct all persons to move, in a crosswind direction, away from the spill to the distance specified—in meters and feet.




(5) Look up the initial PROTECTIVE ACTION DISTANCE shown in Table 1. For a given material, spill size, and whether day or night, Table 1 gives the downwind distance—in kilometers and miles— for which protective actions should be considered. For practical purposes, the Protective Action Zone (i.e., the area in which people are at risk of harmful exposure) is a square, whose length and width are the same as the downwind distance shown in Table 1.

(6) Initiate Protective Actions to the extent possible, beginning with those closest to the spill site and working away from the site in the downwind direction. When a water-reactive TIH producing material is spilled into a river or stream, the source of the toxic gas may move with the current or stretch from the spill point downstream for a substantial distance.

The shape of the area in which protective actions should be taken (the Protective Action Zone) is shown in this figure. The spill is located at the center of the small circle. The larger circle represents the INITIAL ISOLATION zone around the spill.




**NOTE 1: See "Introduction To Table 1 - Initial Isolation And Protective Action Distances" for factors which may increase or decrease Protective Action Distances.**

**NOTE 2: See Table 2 – Water-Reactive Materials which Produce Toxic Gases for the list of gases produced when these materials are spilled in water.**

Call the emergency response telephone number listed on the shipping paper, or the appropriate response agency as soon as possible for additional information on the material, safety precautions, and mitigation procedures.

*Page 298* *Page 299*

**TABLE 1 - INITIAL ISOLATION AND PROTECTIVE ACTION DISTANCES**

*Page 300*

| | | SMALL SPILLS (From a small package or small leak from a large package) | | | | | | LARGE SPILLS (From a large package or from many small packages) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | First ISOLATE in all Directions | | Then PROTECT persons Downwind during- | | | | First ISOLATE in all Directions | | Then PROTECT persons Downwind during- | | | |
| | | | | DAY | | NIGHT | | | | DAY | | NIGHT | |
| ID No. | NAME OF MATERIAL | Meters | (Feet) | Kilometers | (Miles) | Kilometers | (Miles) | Meters | (Feet) | Kilometers | (Miles) | Kilometers | (Miles) |
| 1005<br>1005 | Ammonia, anhydrous<br>Anhydrous ammonia | 30 m | (100 ft) | 0.1 km | (0.1 mi) | 0.2 km | (0.1 mi) | 150 m | (500 ft) | 0.8 km | (0.5 mi) | 2.3 km | (1.4 mi) |
| 1008<br>1008 | Boron trifluoride<br>Boron trifluoride, compressed | 30 m | (100 ft) | 0.1 km | (0.1 mi) | 0.6 km | (0.4 mi) | 300 m | (1000 ft) | 1.9 km | (1.2 mi) | 4.8 km | (3.0 mi) |
| 1016<br>1016 | Carbon monoxide<br>Carbon monoxide, compressed | 30 m | (100 ft) | 0.1 km | (0.1 mi) | 0.1 km | (0.1 mi) | 150 m | (500 ft) | 0.7 km | (0.5 mi) | 2.7 km | (1.7 mi) |
| 1017 | Chlorine | 60 m | (200 ft) | 0.4 km | (0.3 mi) | 1.6 km | (1.0 mi) | 600 m | (2000 ft) | 3.5 km | (2.2 mi) | 8.0 km | (5.0 mi) |
| 1023<br>1023 | Coal gas<br>Coal gas, compressed | 30 m | (100 ft) | 0.1 km | (0.1 mi) | 0.1 km | (0.1 mi) | 60 m | (200 ft) | 0.3 km | (0.2 mi) | 0.4 km | (0.3 mi) |
| 1026<br>1026 | Cyanogen<br>Cyanogen gas | 30 m | (100 ft) | 0.2 km | (0.1 mi) | 0.9 km | (0.5 mi) | 150 m | (500 ft) | 1.0 km | (0.7 mi) | 3.5 km | (2.2 mi) |
| 1040<br>1040 | Ethylene oxide<br>Ethylene oxide with Nitrogen | 30 m | (100 ft) | 0.1 km | (0.1 mi) | 0.2 km | (0.1 mi) | 150 m | (500 ft) | 0.8 km | (0.5 mi) | 2.5 km | (1.6 mi) |
| 1045<br>1045 | Fluorine<br>Fluorine, compressed | 30 m | (100 ft) | 0.1 km | (0.1 mi) | 0.3 km | (0.2 mi) | 150 m | (500 ft) | 0.8 km | (0.5 mi) | 3.1 km | (1.9 mi) |
| 1048 | Hydrogen bromide, anhydrous | 30 m | (100 ft) | 0.1 km | (0.1 mi) | 0.4 km | (0.3 mi) | 300 m | (1000 ft) | 1.5 km | (1.0 mi) | 4.5 km | (2.8 mi) |
| 1050 | Hydrogen chloride, anhydrous | 30 m | (100 ft) | 0.1 km | (0.1 mi) | 0.4 km | (0.2 mi) | 60 m | (200 ft) | 0.3 km | (0.2 mi) | 1.4 km | (0.9 mi) |
| 1051 | AC **(when used as a weapon)** | 100 m | (300 ft) | 0.3 km | (0.2 mi) | 1.1 km | (0.7 mi) | 1000 m | (3000 ft) | 3.8 km | (2.4 mi) | 7.2 km | (4.5 mi) |
| 1051<br><br><br>1051<br>1051 | Hydrocyanic acid, aqueous solutions, with more than 20% Hydrogen cyanide<br>Hydrogen cyanide, anhydrous, stabilized<br>Hydrogen cyanide, stabilized | 60 m | (200 ft) | 0.2 km | (0.1 mi) | 0.6 km | (0.4 mi) | 400 m | (1250 ft) | 1.6 km | (1.0 mi) | 4.1 km | (2.5 mi) |
| 1052 | Hydrogen fluoride, anhydrous | 30 m | (100 ft) | 0.1 km | (0.1 mi) | 0.5 km | (0.3 mi) | 300 m | (1000 ft) | 1.7 km | (1.1 mi) | 3.6 km | (2.2 mi) |

**Figure 4-1** Instructions and example pages from the Initial Isolation and Protective Action Distances table found in the *ERG*.

All responders should be equipped with the latest version of the *ERG* and take time to become familiar with it. A good way to practice is to imagine a particular chemical and credible location or condition in which the chemical might be released. Identify the unique United Nations/North American Hazardous Materials Code (UN/NA) identification number for the chemical, check whether it is highlighted and found in the green section of the book, and determine the recommended emergency actions and PPE that might be required to handle the incident. Also, it is useful to imagine the release occurring in several different areas of your jurisdiction and make some judgments about initial isolation distances or other protective actions in each case. Part of being a prepared responder is to conduct some level of preplanning of your own relative to the credible release scenarios that may exist.

In the orange section of the *ERG*, for example, evacuation distances assume that the listed chemical is involved in a fire. The green section, by comparison, is based on toxicity concerns; materials are listed in this section because they present an extraordinary threat from a health and safety perspective. To that end, responders should understand that the "initial isolation" distances (the distance all persons should be considered for evacuation in all directions) and the "protective action" distances (the downwind distance over which some form of protective actions might be required) are based on the nature of the material, the environmental conditions of the release, and the size of the release. A small spill, for example, means that a spill involves less than 200 liters (approximately 52 gallons) for liquids or less than 300 kilograms (approximately 661 pounds) of a solid.

## Exposures

When considering the potential consequences of a hazardous materials/WMD incident, the on-scene crews must consider how exposures might be affected. In firefighting, the term "exposures" typically refers to those areas adjacent to the fire that might become involved if the fire is left unchecked. For our purposes here, exposures include any people, property, structures, or environments that are subject to influence, damage, or injury as a result of contact with a hazardous material/WMD. The number of exposures is determined by the location of the incident, the physical and chemical properties of the released substance, and the amount of progress that has been made in protecting those exposures (such as people, property, and the environment) by isolating the release site or by taking protective actions such as evacuation or sheltering-in-place. Incidents in urban areas are likely to have a greater potential for exposures; consequently, more resources will likely be needed to protect those exposures from the hazardous materials/WMD.

Isolation of the hazard area is one of the first actions responders must take at a hazardous materials/WMD incident. The general philosophy of isolation revolves around the concept of separating the people from the problem: *Responders and civilians alike must be kept a safe distance from the release site—a vital first step in beginning to establish safe work zones and identify the areas of high hazard.* Isolating the hazard may be accomplished in several ways. Law enforcement officers may be posted a safe distance from the release to create a secure perimeter. Other public safety personnel such as fire fighters may serve the same function, although it is important not to waste the skills of a cache of trained hazardous materials/WMD responders by assigning them to guard doors, other points of ingress or egress from a building, or other contaminated areas. In many cases, responders will stretch a length of barrier tape across roadways, doors, or other access points. Care must be taken, however, not to rely solely on this method of scene control. Quite often, these cordoned-off areas are not respected by other public safety responders or the general public. If and when barrier tape is used, live responders should still ensure the security of the area. Also, keep in mind that the precise type of isolation efforts undertaken will be driven by the nature of the released chemical and the environmental conditions.

Once the hazard is isolated, access is denied to all but a small group of responders who are trained and equipped to enter the contaminated atmosphere. Isolating a contaminated atmosphere is always conjoined in some way with denial of entry (i.e., restriction of access) to the site. Practically speaking, one action cannot exist without the other. Typically, site access control is established so as to control the movement of personnel into and out of a contaminated area.

Evacuation is the removal/relocation of those individuals who may be affected by an approaching release of a hazardous material. If the threat will be sustained over a long period of time, it may be advisable to evacuate people from a predicted or anticipated hazard area, making sure to evacuate those in the most danger first. Most often, awareness level personnel should concentrate on keeping themselves from becoming contaminated. To that end, evacuation efforts do not require personnel to wear PPE or enter contaminated atmospheres. Think of it this way: If you are wearing PPE to move people from one area to another, you may have shifted gears from conducting an evacuation to performing a rescue. The latter responsibilities may or may not be within the scope of your training.

Sheltering-in-place is a method of safeguarding people located near or in a hazardous area by temporarily keeping them in a cleaner atmosphere, usually inside structures. In some cases—for example, with a transitory problem such as a mobile vapor cloud—it is advisable to use a shelter-in-place strategy. This method is desirable only when the population being protected in place can care for themselves, control the air, and the structure can be sealed. Awareness level personnel, for example, could be expected to initiate some form of protective action such as directing civilians away from the contaminated area or directing certain populations of civilians to follow a shelter-in-place approach. Remember that the NFPA 472 standard does not consider awareness level personnel to be responders.

### Reporting the Size and Scope of the Incident

Reporting the estimated physical size of the area affected by a hazardous materials/WMD incident is accomplished by using information available at the scene. If a vehicle is transporting a known amount of material, for example, an estimate of the size of the release might be made by subtracting the amount re-

Figure 4-2 Thermal imaging cameras allow responders to estimate how much material remains in a container.

maining in the container from the maximum capacity of the container. To "see" into containers such as railroad tank cars, steel drums, or cargo tanks and estimate their remaining contents, responders may use thermal imaging cameras (TICs) Figure 4-2.

For example, you might use a TIC to investigate a steel drum discovered in a vacant lot. A quick look at the scene may reveal some wet-looking soil around the base of the drum. By using the TIC, you might be able to determine the percentage of liquid remaining, and make an educated guess about how much could have leaked. Of course, these estimations may be quite rough, especially when it is unknown how much a given vessel may have contained prior to a release. It does, however, allow for some "worst-case scenario" estimations.

Depending on its size, the extent of the release may be expressed in units as small as square feet or as large as square miles. There are no hard and fast rules here: Be as accurate and as clear as possible when communicating with other responders or assisting agencies, or when contacting call centers such as CHEMTREC, CANUTEC, or SETIQ for assistance. Refer back to Chapter 3 for more information on these call centers. Remember that the safety of responders is paramount to maintaining an effective response to any hazardous materials/WMD incident.

## Determining the Concentration of a Released Hazardous Material

Concentration, from the perspective of a chemist, refers to the amount of solute in a given amount of solution. From a practical perspective, a concentrated solution of any kind contains a large amount of solute for a given amount of solution Figure 4-3. A dilute solution, by contrast, contains a small amount of solute for a given solution Figure 4-4.

Consider a natural gas release. If a gas heater were to fail in some way, resulting in a sustained release of natural gas (the solute), a high concentration of gas could build up inside a tightly sealed house (with air being the solution in this instance). The consequence of that accumulation could be an explosion if the gas were to reach the proper proportions and find an ignition source. If the windows or doors of the house were opened, however, the concentration of natural gas would decrease, perhaps becoming so "dilute" that it would pose no significant fire or health hazard. Typically, concentrations of gases are expressed as percentages—think of flammable range as an example. The flammable range of natural gas is 5 percent to 15 percent, meaning that the concentration of vapors must be between these two values if combustion is to occur.

In the preceding example, responders may be called upon to determine the airborne concentration of natural gas within the house. When this step is necessary, the use of specialized detection and monitoring equipment may be required. Using detection and monitoring equipment properly requires some technical expertise, a lot of common sense, and a commitment to continual training. It is a mistake for responders to believe that they can simply turn on a machine, point it in some direction, and expect it to solve the problem. A reading from a gas detector, taken out of context, may cause an entire response to head off in the wrong direction, leading to an unsafe decision or a series of inefficient tactics. The responder must interpret the information the instrument is providing and make decisions based on the information. Always remember that using a detector/monitor entails more than just reading the screen or waiting for an alarm to sound. See Chapter 14 of this text, Mission-Specific Competencies: Air Monitoring and Sampling, for more detail regarding the use of these devices.

Concentrated

Figure 4-3 A concentrated solution of any kind contains a large amount of solute for a given amount of solution.

Diluted

Figure 4-4 A diluted solution contains a small amount of solute for a given solution.

When responding to incidents involving corrosives, it is also important to know the concentration of the released substance. Concentration, when discussing corrosives, is an expression of how much of the acid or the base is dissolved in a solution (usually water). Again, this value is generally expressed as a percentage. Sulfuric acid at a concentration of 97 percent is considered to be "concentrated," whereas the sulfuric acid found in car batteries (approximately 30 percent) is considered to be "dilute." In practical terms, responders should understand whether a released corrosive is concentrated or diluted—but should not confuse *concentration* with the *strength* of the solution. *The words "strong" and "weak" do not correspond with "concentrated" and "dilute," respectively.* The strength of a corrosive refers to the degree of ionization that occurs in a solution, which is determined by the solution's pH. A strong acid such as hydrochloric acid (HCl) is strong even if it's found in a dilute concentration. Acetic acid (vinegar) is considered to be a weaker acid, and it remains a weak acid even when it occurs in high concentrations. In general, strong corrosives will react more vigorously with incompatible materials such as organic substances and will be more aggressive when they come into contact with metallic objects such as metal shelving, shovels, and other items. (For more information on corrosives, refer to Chapter 2 of this text, Hazardous Materials: Properties and Effects.)

To measure pH in the field, hazardous materials/WMD responders can use litmus paper, sometimes referred to as pH paper Figure 4-5. Several styles of pH paper are in use today; refer to the tools used in your own jurisdiction to determine the specific styles of pH paper you may be called upon to use. Although specialized laboratory instruments are also used to measure pH, these kinds of tools are rarely deployed in the field.

## Skin Contact Hazards

Many hazardous substances on the market today have the ability to produce harmful effects on the unprotected or inadequately protected human body. The skin can absorb harmful toxins without any sensation to the skin itself. Given this fact, responders should not rely on pain or irritation as a warning sign of absorption. Some poisons (the nerve agent VX, for example) are so concentrated that just a few drops placed on the skin may result in death.

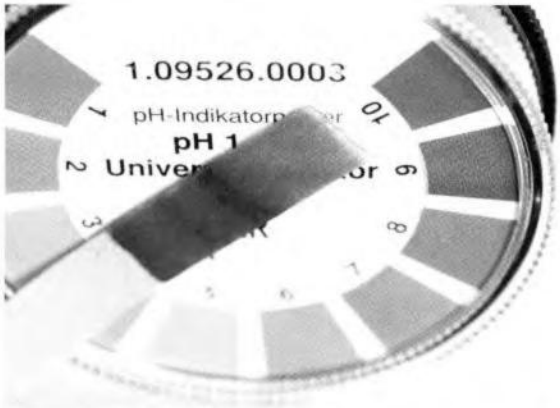



Figure 4-5 Litmus paper (pH strips) is used to determine the hazardous material's pH.

Skin absorption is enhanced by abrasions, cuts, heat, and moisture—all of which allow materials to enter the body more easily. This relationship can create critical problems for responders who are working at incidents that involve any form of chemical or biological agents. Responders with large open cuts, rashes, or abrasions should be prohibited from working in areas where they may be exposed to hazardous materials/WMD. Smaller cuts or abrasions should be covered with nonporous dressings.

The rate of absorption can vary depending on the body part that is exposed. For example, chemicals can be absorbed through the skin on the scalp much faster than they are absorbed through the skin on the forearm. The high absorbency rate associated with the eyes makes them one of the fastest means of exposure. For example, a chemical may quickly enter the body through this route when it is splashed directly into the eyes, carried from a fire by toxic smoke particles, or when exposed to gases or vapors.

Chemicals such as corrosives will immediately damage skin or body tissues upon contact. Acids, for example, have a strong affinity for moisture and can create significant skin and respiratory tract burns. In contrast, alkaline materials dissolve the fats and lipids that make up skin tissue and change solid tissue into a soapy-like liquid. This process is similar to the way caustic cleaning solutions dissolve grease and other materials in sinks and drains. As a result, alkaline burns are often much deeper and more destructive than are acid burns.

# Plan an Initial Response

Planning a response boils down to understanding the nature of an incident and determining a course of action that will favorably change the outcome. On the surface, this seems like a straightforward, uncomplicated task. In truth, the decision to act can be a weighty one, fraught with many pitfalls and dangers. When planning an initial hazardous materials/WMD incident response, it is important to be mindful of the safety of the responding personnel. The responders are there to isolate, contain, and/or remedy the problem—not to become part of it. Proper incident planning will keep responders safe and provide a means to control the incident effectively, preventing further harm to persons or property.

Tactical control objectives are actions that may or may not involve the actual stopping of the leak or release of a hazardous material. In some cases, tactical objectives may include preventing further injury and controlling or containing the spread of the hazardous material. An example of a tactical control objective may include identifying and securing potential ignition sources when flammable liquids and gases have been released. Common examples of ignition sources include open flames from pilot lights or other sources, arcs occurring when electrical switches are turned on or off, static electricity, and/or smoking materials.

The information obtained from the initial call for help is used to determine the safest, most effective, and fastest route to

Figure 4-6 Approach a hazardous materials incident cautiously.

the hazardous materials/WMD scene. Choose a route that approaches the scene from an upwind and upgrade direction, so that natural wind currents blow the hazardous material vapors away from arriving responders Figure 4-6. A route that places the responders uphill as well as upwind of the site is also desirable, so that a liquid or vapor hazardous material flows away from responders.

Responders need to know as much as possible about the material involved. Is the material a solid, a liquid, or a gas? Is it contained in a drum, a barrel, or a pressurized tank? Is the spill still in progress (dynamic) or has it ceased (static)? The response to a spill of a solid hazardous material will differ from the response to a liquid-release incident or a vapor-release incident. A solid may be easily contained, whereas a released gas can be widespread and constantly moving, depending on the gas characteristics and weather conditions Figure 4-7.

The characteristics of the affected area near the location of the spill or leak are also important factors in planning the response to an incident. If an area is heavily populated, evacuation procedures may be established very early in the course of the incident. If the area is sparsely populated and rural, isolating the area from anyone trying to enter the location may be the top priority. A high-traffic area such as a major highway would necessitate immediate rerouting of traffic, especially during rush hours.

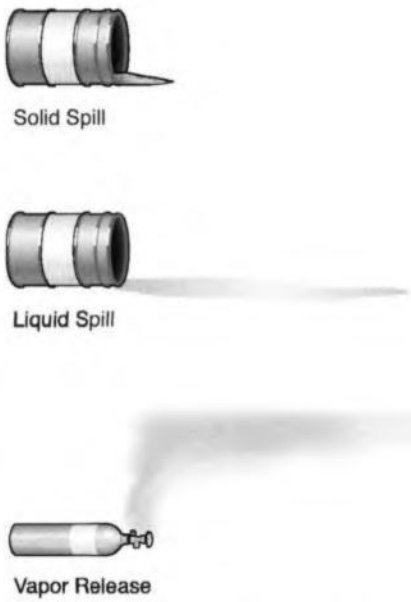



Figure 4-7 The response to a spill of a solid hazardous material will differ from the response to a liquid-release or vapor-release incident.

## Response Objectives

Response objectives should be measurable, flexible, and time sensitive; they should also be based on the chosen strategy. Some examples might include the following:

- A three-person team will construct a dirt berm around the drain at the south end of the leaking tanker so as to protect the adjacent waterway. This task will need to be completed in the next 30 minutes.
- A two-person team, wearing Level B ensemble, will immediately enter the steel door on the east side of the building and shut down the ventilation system.

In some cases, several response objectives may be developed to solve a problem. To be effective and meaningful, however, those objectives need to be tied to the reason you chose to take action in the first place. Again, if you don't understand why you are taking action, reevaluate the situation so that you can better understand the problem.

## Secondary Attacks and Devices

In today's political climate, first responders of all disciplines should be aware of the potential for secondary attacks or devices and understand the need for acknowledging them in response objectives. Implementing a secondary attack on responders is a tactic that many terrorist organizations use to make their attacks even more dramatic. For this reason, responders must be able to assess the potential for secondary attacks and devices. This may be much easier said than done, however, as the indicators of secondary attacks or devices can be difficult to locate.

Terrorists who want to injure responding personnel with a secondary device or attack will typically make the initial attack very dramatic to draw responders into very close proximity to the scene. Indeed, the primary attack may purposely injure members of the public to draw responders into the scene. As they begin to treat victims, the secondary attack then takes place.

All responders should maintain good situational awareness at every emergency scene, but especially in cases where one detonation has already taken place. In particular, their actions should include a brief scan of areas where secondary devices are likely to be placed. You may seek the assistance of someone familiar with the area—that person may be more attuned to noticing unusual items. Avoid touching or moving anything that is not critical to the operation or anything that may reasonably conceal an explosive device. The NFPA 473, *Standard for Competencies for EMS Personnel Responding to Hazardous Materials/Weapons of Mass Destruction Incidents,* EVADE mnemonic serves as a useful reminder of some key points when it comes to secondary devices:

**Responder Safety Tips**

More than 70 percent of all terrorist acts worldwide involve explosives.

- Evaluate the scene for areas where secondary devices are likely to be placed.
- Visually scan operating areas for a secondary device before providing patient care.
- Avoid touching or moving anything that may conceal an explosive device.
- Designate and enforce scene control zones.
- Evacuate victims, other responders, and nonessential personnel as quickly and safely as possible.

### Defensive Actions

Examples of defensive actions that can be taken include diking and damming; stopping the flow of a substance remotely from a valve or shut-off; diluting or diverting the material; or suppressing or dispersing vapor. These and other actions are covered in detail in Chapter 11 of this text, Mission-Specific Competencies: Product Control.

## Personal Protective Equipment

The determination of which PPE is needed is based on the hazardous material involved, the specific hazards present, and the physical state of the material, along with a consideration of the tasks to be performed by the operations level responder. Chapter 7 of this text, Mission-Specific Competencies: Personal Protective Equipment, discusses proper PPE for a hazardous materials/WMD incident in detail.

In the realm of hazardous materials/WMD response, the selection and use of chemical-protective clothing may have the greatest direct impact on responder health and safety. Without the proper PPE, responders place themselves at risk of suffering harmful exposures. Corrosives such as concentrated sulfuric acid and hydrochloric acid, as well as caustic substances such as sodium hydroxide, for example, can damage the skin. The human body is also susceptible to the adverse effects of solvents such as methylene chloride and toluene, which may penetrate the skin and cause systemic health effects. Some poisons—the nerve agent VX, for example—are highly toxic and can be fatal in small doses.

Skin protection, however, is just one factor to be considered when discussing PPE. Anyone planning to work in a contaminated atmosphere must also place a high priority on respiratory protection. Respiratory protection is so important that it can be viewed as the defining element of PPE. The head-to-toe ensemble is not complete until the hazards have been identified, and the respiratory protection has been properly matched to both the hazard *and* the garment.

Keep in mind that PPE is not intended to function as an impenetrable suit of armor: It has limitations!

The National Fire Protection Association (NFPA) publishes protective clothing standards to provide guidance on the performance of certain types of chemical-protective garments. NFPA 1991, for example, is the *Standard on Vapor-Protective Ensembles for Hazardous Material Emergencies*. NFPA 1992, *Standard on Liquid Splash-Protective Ensembles and Clothing for Hazardous Materials Emergencies*, covers a different type of chemical-protective garment. The NFPA also acknowledges the importance of chemical protective garments as it relates to WMD response. To obtain guidance in this area, responders may reference NFPA 1994, *Standard on Protective Ensembles for First Responders to CBRN (Chemical, Biological, Radiological, and Nuclear) Terrorism Incidents*.

The NFPA does not "certify" any garments. This is a common misperception in the hazardous materials/WMD response industry. Instead, the intent of the NFPA clothing standards is to provide guidance on manufacturing quality and performance standards. A third-party testing laboratory carries out the testing and "certifies" the garment in question. In short, the NFPA publishes performance standards (durability, flammability, chemical resistance, and cold temperature); third-party laboratories then test manufacturers' garments to determine if they meet the NFPA standards. Much like other NFPA committees, the Technical Committee for Chemical Protective Clothing consists of end users (responders), manufacturers, government representatives, and other recognized experts in the field.

When it comes to the selection and use of PPE, responders must understand how standards and regulations influence their decision making in the field. The NFPA protective clothing standards do not tell you when, or under which conditions, to wear a particular level of chemical protection. Rather, these standards are performance documents for the garments only—they are not intended to guide responders. For guidance on which level of chemical protection to use under specific conditions, you may consult the OSHA HAZWOPER *(HAZardous Waste OPerations and Emergency Response)* regulation, 29 CFR 1910.120 (refer to Chapter 1 for a review of this regulation); Appendix B of the OSHA HAZWOPER regulation offers guidance on which components should be worn for certain levels of protection, and under which conditions the various levels of protection should be chosen.

In addition to the performance standards, responders must be aware of the procedures for cleaning, disinfecting, and inspecting PPE. These procedures may vary from manufacturer to manufacturer, so it is important for all responders working in an Authority Having Jurisdiction (AHJ) to understand what is required to maintain the PPE.

Some types of PPE—primarily reusable garments—are required to be tested at regular intervals and after each use. Individual manufacturers will have well-defined procedures for the maintenance, testing, and inspection of their particular equipment. Prior to purchasing any PPE, the AHJ should understand

**Responder Safety Tips**

The NFPA does not "certify" chemical-protective garments of any kind but rather sets performance standards for the garments.

# Voices *of* Experience

My engine company was dispatched to a small fire in a garbage dump. As we arrived on the scene, we could see a small fire burning about 200 yards away. We dismounted and walked closer to determine whether to pull a line or try to hit the fire with the master stream. My engine carried 1000 gallons of water, so we felt confident that we could handle a refuse fire.

We were approximately 20 feet away when bright red smoke began billowing from the burning pile of junk. I had never seen anything like it before. We immediately pulled back, and I ordered the crew to don SCBA. You do not have to be a chemist to understand that junk fire smoke is not typically bright red.

*"After estimating and predicting the risks involved, we planned our actions accordingly."*

Common sense prevailed, and we exercised caution by moving the engine back toward the entrance road to stay upwind of the red smoke. I called dispatch and reported that we had a possible hazardous materials fire. I was told to stand by for a hazardous materials officer. When the hazardous materials officer arrived, it was decided that we should let the fire burn out. We later learned that someone had piled old tires around abandoned drums of unknown liquid and added a few gallons of gasoline. It was a cheap (and fast) way to dispose of the chemicals.

This was my first experience as a company officer dealing with a hazardous materials incident. At that time, we did not know a lot about hazardous materials. I was not sure if we should use water on this fire, so I elected to do nothing. After estimating and predicting the risks involved, we planned our actions accordingly. We understood that this incident had significant potential to become a much larger event.

This call convinced me that I needed to know a lot more about hazardous materials. Shortly after the incident, I registered for a class on hazardous materials chemistry. I was later appointed to be the coordinator to start the hazardous materials team for our county.

Rick Emery
Lake County Hazardous Materials Team (Retired)
Vernon Hills, Illinois

what is required in terms of maintenance and upkeep, including the cleaning and disinfection of the PPE.

Most types of chemical-protective garments should be stored in a cool dry place, free of significant temperature swings and/or high levels of humidity. 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.

## Hazardous Materials: Specific Personal Protective Equipment

Several types and levels of PPE may be selected for use at a hazardous materials/WMD incident. These levels are spelled out in great detail in OSHA's HAZWOPER regulations and in local jurisdictional regulations. This section reviews the protective qualities of various ensembles, from the lowest level of protection to the greatest, and discusses the selection criteria for each level.

### Street Clothing and Work Uniforms

At the lower end of the PPE spectrum is normal street clothing or work uniforms, which offer the least amount of protection in a hazardous materials/WMD emergency Figure 4-8. Work uniforms may prevent a "nuisance" powder from coming into direct contact with the skin but offer no chemical protection. Typically, those personnel performing support functions away from the areas of contamination wear normal work uniforms.

### Structural Firefighting Protective Clothing

The next level of protection is provided by structural firefighting protective equipment Figure 4-9. Structural firefighting gear is not recognized as a chemical-protective ensemble, though it does have a place at a hazardous materials/WMD incident. Many support functions can be carried out in structural fire fighter's gear. In some cases (such as during incidents involving chemicals with low toxicity and/or high flammability), structural gear may be safer than traditional types of chemical-protective clothing. A full set of structural fire fighter's gear includes a helmet, a bunker coat, bunker pants, boots, gloves, a hood, SCBA, and a personal alert safety system (PASS) device.

Figure 4-8 A Nomex jumpsuit.

Figure 4-9 Standard structural firefighting gear.

### High-Temperature-Protective Clothing and Equipment

High-temperature-protective equipment is a level above structural fire fighter's gear Figure 4-10. This type of personal protective equipment shields the wearer during short-term exposures to high temperatures. Sometimes referred to as a proximity or entry suit, high-temperature-protective equipment allows the properly trained fire fighter to work in extreme fire conditions. It provides protection against high temperatures

**Responder Tips**

Some fire fighters may have difficulty finding structural protective clothing that fits properly. There may be gaps at the waist, wrists, and neck. A fire department should issue PPE that properly fits each fire fighter, regardless of gender, size, or shape.

Figure 4-10 High-temperature-protective equipment protects the wearer from high temperatures during a short exposure.

only—it is not designed to protect the fire fighter from hazardous materials/WMD.

## Chemical-Protective Clothing and Equipment

Chemical-protective clothing is unique in the fact that it is designed to prevent chemicals from coming in contact with the body. Not all chemical-protective clothing is the same, and each type/brand/style may offer varying degrees of resistance. There is no single chemical-protective garment on the market that will protect you from everything. Manufacturers supply compatibility charts with all protective equipment; these charts are intended to assist you in choosing the right chemical-protective clothing. 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 requirements include flexibility, abrasion, temperature resistance, shelf life, and sizing criteria.

Chemical resistance is the ability of the garment to resist damage or become compromised as a result of direct contact with a chemical. 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 (e.g., zippers), seams, porous materials, pinholes, or other imperfections in the material. Although liquids are most likely to penetrate a material, solids (e.g., asbestos) can also penetrate protective clothing materials.

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.

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.

Chemical-protective clothing can be constructed as a single-piece or multiple-piece garment. For example, a single-piece garment completely encloses the wearer and is referred to as an encapsulated suit. A variety of materials are used to manufacture encapsulating (and nonencapsulating) multiple-piece garments. The most common include butyl rubber, Tyvek, Saranex, polyvinyl chloride, and Viton, which are used either singly or in multiple layers of several materials. Special chemical-protective clothing is adequate for some chemicals, yet useless for other chemicals; no single material provides satisfactory protection from all chemicals.

Fully encapsulating protective clothing offers full body protection from highly contaminated environments and requires supplied-air respiratory protection devices such as SCBA. NFPA 1991, *Standard for Vapor-Protective Ensembles for Hazardous Materials Emergencies*, sets the performance standards for these types of garments, more correctly referred to as a vapor-protective clothing Figure 4-11. NFPA 1991

Figure 4-11 Vapor-protective clothing retains body heat and increases the possibility of heat-related emergencies.

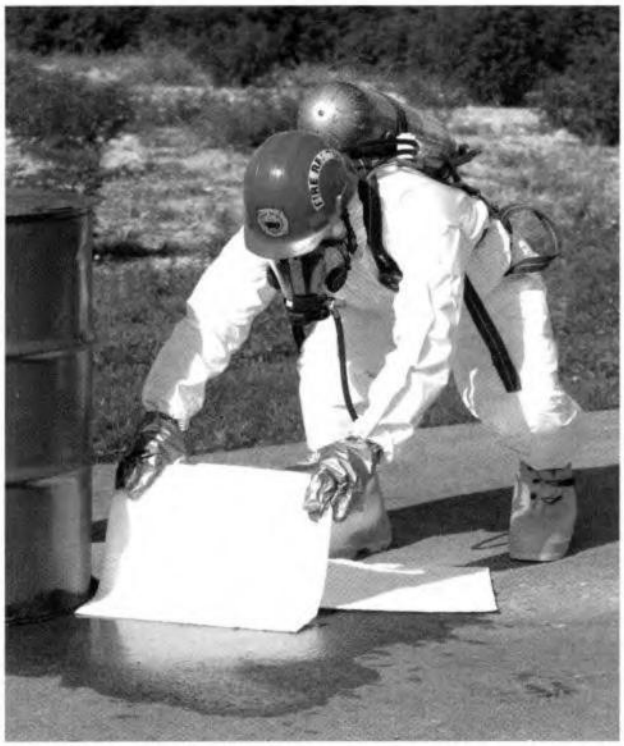


Figure 4-12 Liquid splash–protective clothing must be worn when there is the danger of chemical splashes.

garments are tested for permeation resistance against 21 standard chemicals, several toxic industrial chemicals, and two chemical weapons.

Liquid splash–protective clothing is designed to protect the wearer from chemical splashes Figure 4-12. It does not provide total body protection from gases or vapors, however, and should not be used for incidents involving liquids that emit vapors known to affect or be absorbed through the skin. NFPA 1992, *Standard on Liquid Splash-Protective Ensembles and Clothing for Hazardous Materials Emergencies,* is the performance document for liquid-splash garments and ensembles. This type of equipment is tested for penetration resistance against a test battery of five chemicals. The tests include no gases, as this level of protection is not considered to be vapor protection.

## Chemical-Protective Clothing Ratings

Chemical-protective clothing is rated for its effectiveness in several different ways. The U.S. Environmental Protection Agency (EPA) defines levels of protection, using an alphabetic system.

### Level A

Level A ensemble consists of a fully encapsulating garment that completely envelops both the wearer and the respiratory protection, gloves, boots, and communications equipment. The Level A ensemble should be used when the hazardous material identified requires the highest level of protection for the skin, eyes, and respiratory tract. Typically, this level is indicated when the operating environment is above IDLH values for skin absorption. Level A ensemble is effective against vapors, gases, mists, and even dusts Figure 4-13.

Ensembles worn as Level A protection must meet the requirements for vapor-protective clothing as outlined in the most current edition of NFPA 1991, *Standard on Vapor-Protective Ensembles for Hazardous Materials Emergencies.*

Recommended PPE of Level A ensemble includes the following components:

- SCBA or Supplied-air respirators SAR
- Fully encapsulating vapor-protective chemical-resistant suit
- Inner and outer chemical-resistant gloves
- Chemical-resistant safety boots/shoes (including steel shank and toe)
- Two-way radio

Optional PPE for Level A ensemble includes the following components:

- Coveralls
- Cooling vest
- Long cotton underwear
- Hard hat
- Disposable gloves and boot covers

Figure 4-13 Level A ensemble envelops the wearer in a totally encapsulating suit.

## Level B

Level B ensemble consists of chemical-protective clothing, boots, gloves, and SCBA Figure 4-14. This type of PPE should be used when the type and atmospheric concentration of identified substances require a high level of respiratory protection but less skin protection. To that end, the defining piece of equipment with Level B ensembles is an SCBA or some other type of SAR. Garments and ensembles that are worn for Level B protection should comply with the performance standards outlined in NFPA 1992, *Standard on Liquid Splash-Protective Ensembles and Clothing for Hazardous Materials Emergencies*.

Several types of single-piece and multiple-piece garments on the market can be used to create a Level B ensemble. It is the respiratory protection, however, that distinguishes Level B ensembles from the next (lower) level of protection (Level C).

The types of gloves and boots worn depend on the identified chemical. Wrists and ankles must be properly sealed to prevent splashed liquids from contacting skin.

Recommended PPE worn as part of a Level B ensemble includes the following components:

- SCBA or SAR
- Chemical-resistant clothing
- Inner and outer chemical-resistant gloves
- Chemical-resistant safety boots/shoes
- Two-way radio

Figure 4-14 A Level B ensemble provides a high level of respiratory protection but less skin protection.

### Responder Safety Tips

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

Optional PPE for a Level B ensemble includes the following components:

- Cooling vest
- Coveralls
- Disposable gloves and boot covers
- Face shield
- Long cotton underwear
- Hard hat

## Level C

Level C ensemble consists of standard work clothing plus chemical-protective clothing, chemical-resistant gloves, and a form of respiratory protection. Typically, Level C ensembles are worn with an air-purifying respirator (APR) or a powered air-purifying respirator (PAPR); both are discussed in more detail later in this chapter. The APR could be a half-face (with eye protection) or a full-face mask. Head protection (hard hat) is also required. A Level C ensemble is appropriate when the type of airborne substance is known, its concentration is measured, the criteria for using APRs are met (see the respiratory protection section of this chapter), and skin and eye exposure is unlikely Figure 4-15. The garments selected must meet the performance requirements outlined in NFPA 1992, *Standard on Liquid Splash-Protective Ensembles and Clothing for Hazardous Materials Emergencies*.

Recommended PPE for a Level C ensemble includes the following components:

- Full-face APR
- Chemical-resistant clothing
- Inner and outer chemical-resistant gloves
- Chemical-resistant safety boots/shoes
- Two-way radio

Optional PPE for a Level C ensemble includes the following components:

- Coveralls
- Disposable gloves and boot covers
- Face shield
- Escape mask
- Long cotton underwear
- Hard hat

## Level D

Level D ensemble is the lowest level of protection. This type of ensemble typically comprises coveralls, work shoes, hard hat, gloves, and standard work clothing Figure 4-16. It should be used only when the atmosphere contains no known hazard, and when work functions preclude splashes, immersion, or the

Figure 4-15 A Level C ensemble includes chemical-protective clothing and gloves as well as respiratory protection.

potential for unexpected inhalation of or contact with hazardous levels of chemicals. Level D ensemble should be used for nuisance contamination (such as dust) only; it should not be worn on any site where respiratory or skin hazards are known to exist.

Recommended PPE for a Level D ensemble includes the following components:

- Coveralls
- Safety boots/shoes
- Safety glasses or chemical-splash goggles
- Hard hat

Optional PPE for a Level D ensemble includes the following components:

- Gloves
- Escape mask
- Face shield

A responder may wear liquid splash–protective clothing over or under structural firefighting clothing in some situations. This multiple-PPE approach provides limited chemical-splash and thermal protection. Those trained to the operational level can wear liquid splash–protective clothing when they are assigned to enter the initial site, protect decontamination personnel, 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

Figure 4-16 The Level D ensemble is primarily a work uniform that includes coveralls and provides minimal protection.

protective ensembles and garments (including respiratory protection) specific to weapons of mass destruction. CBRN stands for "chemical, biological, radiological, and nuclear." This standard covers three classes of garments (Classes 2, 3, and 4), which differs from the traditional levels of protection listed in the EPA regulation (Levels A, B, C, and D). The main difference between these classifications is that NFPA 1994 covers the performance of the garments *and* factors in the performance requirements of the respiratory protection. This consideration is critical when it comes to WMD events because some of the chemicals may cause the components of an APR or SCBA to fail, thereby exposing the responder to a highly toxic environment. Essentially, the NFPA standard acknowledges that the entire ensemble is only as good as the individual components. Based on that criterion, NFPA 1994 requires that all components be certified to perform in a CBRN environment. NFPA 1994 typifies a thought process about PPE that should extend beyond the standard—namely, chemical-protective clothing should be thought of as a *system*.

To help clarify the levels of protection, the NFPA 1994 classes are described here:

- Class 2: Liquid-splash garment performance with SCBA. (Class 2 standards for PPE are in line with the CBRN requirements for SCBA.)

- Class 3: Liquid-splash garment performance with APR. (Class 2 standards for PPE are in line with the CBRN requirements for APR.)
- Class 4: Performance requirements for particles and liquid-borne viral protection.

The CBRN performance requirements for SCBA and APR were born out of the terrorist attacks that occurred on September 11, 2001. In response to the growing threat of terrorism, NIOSH set performance guidelines for SCBA and APR relative to anticipated WMD incidents. In addition to meeting the requirements of NFPA 1981, *Standard on Open-Circuit Self-Contained Breathing Apparatus (SCBA) for Emergency Services*, any SCBA or APR with a NIOSH CBRN certification must have passed a battery of tests that measured their performance against sarin and sulfur mustard. From a practical standpoint, these tests were intended to ensure that the components of the respiratory protection would stand up to the aggressive nature of these chemicals. To reiterate, NFPA 1994 is intended to serve as an integrated performance guideline, factoring in both the garment and the respiratory protection used.

## Physical Capability Requirements

Hazardous materials/WMD response operations put a great deal of physiological and psychological stress on responders. During the incident, personnel may be exposed to both chemical and physical hazards. They may face life-threatening emergencies, such as fire and explosions, or they may develop heat or cold stress while wearing protective clothing or working under extreme temperatures. For these reasons, every emergency response organization should have a comprehensive health and safety management program. The components of a health and safety management system for hazardous materials responders are outlined in the OSHA HAZWOPER regulation. Briefly, a health and safety program should include the following broad elements: medical surveillance including pre-employment screening and periodic medical examinations, treatment plans for acute on-scene illness and injury, thorough recordkeeping of all elements of the program, and a mechanism to periodically review the entire process.

The medical surveillance piece of the overall program is the cornerstone of an effective health and safety management system for responders. The two primary objectives of a medical surveillance program are to determine whether an individual can perform his or her assigned duties, including the use of personal protective clothing and equipment, and to detect any changes in body system functions caused by physical or chemical exposures.

As part of a medical surveillance program, responders should be examined by a physician once a year or biennially based on the physician's recommendations. During this examination, the physician may perform—among other things—a routine exam based on the expected tasks the employee may perform, including wearing PPE; conduct a health questionnaire; and take X-rays and perform a respiratory function test to measure lung capacity and lung function. The physician may also evaluate an individual's fitness for wearing SCBA and other respiratory protection devices. The specific requirements for any responder who is assigned to any duty where any form of respiratory protection will be used can be found in 29 CFR 1910.134, OSHA's respiratory protection standard. Additional guidance may be found in the OSHA/EPA/NIOSH/USCG (United States Coast Guard) document entitled *Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities*.

Medical monitoring and support differ in several ways from a medical surveillance program. Medical monitoring is the on-scene evaluation of response personnel who may experience adverse effects because of exposure to heat, cold, stress, or hazardous materials. Such monitoring can quickly identify problems so they can be treated in a timely fashion, thereby preventing severe adverse effects and maintaining the optimal health and safety of on-scene personnel. Medical monitoring, as a support function that takes place on the scene of an emergency, is covered in depth in Chapter 5.

### Responder Safety Tips

The term "CBRN certified," when used in reference to SCBA and APR, refers to SCBA and APR that are safe to use during a chemical, biological, radiological, or nuclear incident. CBRN-certified SCBA and APR have undergone rigorous testing to ensure their integrity during such incidents.

An SCBA provides a high level of protection at a hazardous materials/WMD incident. To comply with NFPA 1981, *Standard on Open-Circuit Self-Contained Breathing Apparatus (SCBA) for Emergency Services*, positive-pressure CBRN-certified units must maintain an air flow inside the mask at all times. This is a very important feature when responders are operating in an environment characterized by airborne contamination.

The most common types of SCBA are referred to as 30- 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- and 60-minute designations, but the time will vary depending on the wearer's respiratory rate, workload, and other environmental factors.

The extra weight and reduced visibility are other 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 when determining whether SCBA is appropriate. Any responder called upon to wear an SCBA should be fully trained by the AHJ prior to operating in a contaminated environment. All responders should follow manufacturers' recommendations for using, cleaning, filling, and servicing the units they use.

## Positive-Pressure Self-Contained Breathing Apparatus

Respiratory protection, which in the fire service is commonly provided by SCBA, is an important form of respiratory protection at a hazardous materials/WMD incident Figure 4-17 ▸. Use of positive-pressure SCBA prevents both inhalation and ingestion exposures (two primary routes of exposure), and should be mandatory for fire service personnel. SCBA carries its own

Figure 4-17 SCBA carries its own air supply, a factor that limits the amount of air and time the user has to complete the job.

Figure 4-18 A supplied-air respirator is less bulky than an SCBA but is limited by the length and structural integrity of the air hose.

air supply, a factor that limits the amount of air and time the user has to complete the job.

## Supplied-Air Respirators

Supplied-air respirators (SARs), also referred to as positive-pressure air-line respirators (with escape units), use an external air source such as a compressor or a compressed air 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. These units are equipped with a small "escape cylinder" of compressed air. Escape cylinders typically provide the user with approximately 5 minutes of breathing air. SARs may be less bulky and weigh less than SCBA, but the length of the air hose may limit movement and there is potential for incompatibilities of the hose with the product Figure 4-18 ▸.

## Closed-Circuit SCBA

Some hazardous materials/WMD response teams use a form of respiratory protection referred to as closed-circuit self-contained breathing apparatus. Also commonly referred to as a "rebreather," this type of unit can be used when long work periods are required. The basic operating principle is different than the SCBA in that exhaled air is scrubbed free of carbon dioxide, supplemented with a small amount of oxygen, and "rebreathed" by the wearer. No exhaled air is released to the outside environment, making this type of unit a closed-circuit system. The earliest rebreathers were developed in the mid-1800s and were used primarily by mine workers.

The operating principles are the same for SAR and SCBA, but the application and need for each may be vastly different.

## Air-Purifying Respirators

Air-purifying respirators (APRs) are filtering devices or particulate respirators that remove particulates, vapors and contaminants from the air before it is inhaled. They should be worn only in atmospheres where the type and quantity of the contaminants are known and where sufficient oxygen for breathing is available. APRs should not be used when the atmosphere is IDLH. APRs may be appropriate for operations involving volatile solids and for remedial clean-up and recovery operations where the type and concentration of contaminants are verifiable Figure 4-19 ▸.

These devices range from full-face piece, dual-cartridge masks, to half-mask, face piece–mounted cartridges with no eye protection. APRs do not have a separate source of air, but rather filter and purify ambient air before it is inhaled. The models used in environments containing hazardous gases or vapors are commonly equipped with an absorbent material that soaks up or reacts with the gas. Consequently, cartridge selection is based on the expected contaminants. Particle-removing respirators use a mechanical filter to separate the contaminants from

Figure 4-19 Air-purifying respirators can be used only where there is sufficient oxygen in the atmosphere.

the air. Both types of devices require that the ambient atmosphere contain a minimum of 19.5 percent oxygen.

APRs are easy to wear, but they do have some drawbacks. Because filtering cartridges are specific to expected contaminants, these devices will be ineffective if the contaminant changes suddenly, possibly endangering the lives of responders. The air must also be continually monitored for both the known substance and the ambient oxygen level throughout the incident. For these reasons, APRs should not be employed at hazardous materials/WMD incidents until qualified personnel have tested the ambient atmosphere and determined that the devices can be used safely.

### Powered Air-Purifying Respirators

Powered air-purifying respirators (PAPRs) are similar in function to the standard APR described earlier, but include a small fan to help circulate air into the mask. The fan unit is battery powered and worn around the waist. The fan draws outside air through the filters and into the mask via a low-pressure hose. PAPRs are not considered to be true positive-pressure units like an SCBA because it is possible for the wearer to outbreathe the flow of supplied air, thereby creating a negative pressure situation inside the mask. The main advantage of the PAPR is that it diminishes the work of breathing of the wearer, helps reduce fogging in the mask, and provides a constant flow of cool air across the face.

**Responder Tips**

The NFPA standards provide guidance on the performance of various types of chemical-protective garments. OSHA regulations provide performance guidance for responders!

Figure 4-20 There must be a plan in place for decontamination at every hazardous materials/WMD incident.

## Decontamination

Even though there should be no intentional contact with the hazardous material involved in a hazardous materials/WMD incident, a procedure or a plan must be established to decontaminate anyone who becomes contaminated Figure 4-20. According to NFPA 472, contamination is "the process of transferring a hazardous material, or the hazardous component of a weapon of mass destruction (WMD), from its source to people, animals, the environment, or equipment, that can act as a carrier." Decontamination is "the physical and/or chemical process of reducing and preventing the spread of contaminants from people, animals, the environment, or equipment involved at hazardous materials/weapons of mass destruction (WMD) incidents."

Decontamination makes personnel, equipment, and supplies safe by removing or eliminating the offending substances. Proper decontamination is essential at every hazardous materials/WMD incident so as to ensure the safety of personnel and property. Several types of decontamination are covered in detail in this text. See Chapter 8, Mission-Specific Competencies: Technical Decontamination and Chapter 9, Mission-Specific Competencies: Mass Decontamination. In this section, the focus is on life safety and emergency decontamination.

### Emergency Decontamination

Emergency decontamination is the process of getting the bulk of contaminants off a victim as rapidly as possible. This procedure is undertaken in potentially life-threatening situations without the formal establishment of a decontamination corridor, a controlled area located within the warm zone where decontamination is performed. A more formal and detailed decontamination process may follow later. Emergency decontamination usually involves removing contaminated clothing and dousing the victim with large quantities of water Figure 4-21.

If a decontamination corridor does not exist, responders should isolate the exposed victims in a contained area and

Figure 4-21 Emergency decontamination involves the immediate removal of contaminated clothing.

establish an emergency decontamination area. If possible, try to prevent the runoff from getting into drains, streams, or ponds; instead, divert the stream of water into an area where it can be treated or disposed of later. Emergency decontamination can easily be accomplished from a fire engine. Simply pull a handline, maneuver it into a circle, throw a tarp over the middle of the circle, and pull a booster line or other small handline to accomplish the decontamination. This technique is a quick way to handle a conscious victim of a chemical exposure.

If adequate decontamination is not performed, the patient should not be allowed into the transport ambulance or the emergency room at the hospital Also, it is important to obtain a material safety data sheet (MSDS) for the substance to which the person was exposed, and to make sure the information goes to the hospital with the patient.

Always ensure your own safety first before attempting decontamination of others. Avoid touching contaminated patients and/or entering contaminated environments without the proper level of protection. You will be no help in resolving the incident if you become a victim, too!

Refer back to the scenario at the beginning of the chapter. Would the patient be a candidate for emergency decontamination? If so, how could that process be accomplished at a fixed facility? Most fixed facilities that use chemicals will have emergency safety showers and eye wash stations available to the employees. These sites may be the most easily accessible locations in which responders can perform emergency decontamination. The water is clean and readily available; also, employees of such a facility have typically been trained to use the safety showers. But remember that indoor safety showers are in rooms that generally have no drains, because the runoff should not flow into drains and collection tanks until it has been treated. Be prepared for a large clean-up process after activating a safety shower! Chapter 5, Implementing the Planned Response, describes the steps involved in an emergency decontamination.

## Secondary Contamination

Secondary contamination, also known as cross-contamination, is the process of transferring a hazardous material from its source to people, animals, the environment, or equipment, all of which may act as carriers of the contaminant. Secondary contamination occurs when a contaminated person or object comes into direct contact with another person or object. It may happen in several ways:

- A contaminated victim comes into physical contact with another person.
- A bystander or responder comes into contact with a contaminated object from the hot zone (the area immediately around and adjacent to the incident).
- A decontaminated responder reenters the decontamination area and comes into contact with a contaminated person or object.

Because secondary contamination can occur in so many ways, areas at every hazardous materials/WMD incident should be designated as hot, warm, or cold, based on safety considerations and the degree of the hazard found in the area. These so-called control zones should be established, clearly marked, and enforced at hazardous materials/WMD incidents. Establishing control zones is discussed in greater detail in Chapter 5, Implementing the Planned Response.

**Responder Tips**

An effective emergency decontamination operation depends on an understanding of the contaminant and its chemical and physical properties.

**Responder Tips**

By removing the appropriate clothing of a contaminated victim, you have significantly reduced the exposure.

# Wrap-Up

## Chief Concepts

- The first priority for all responders is to ensure their own safety while operating at the scene.
- Hazardous materials/WMD incident response priorities should be based on the need to protect and/or reduce the threat to life, property, critical systems, and the environment.
- To have some frame of reference for the degree of harm a substance may pose, responders should have a basic understanding of some commonly used terms and definitions.
- Gather information from detection and monitoring devices, bystanders, reference sources, and environmental conditions to obtain a clear picture of the incident as a whole.
- Exposures can include people, property, structures, or the environment that are subject to influence, damage, or injury as a result of contact with a hazardous material/WMD.
- Immediate protective actions include isolation of the hazard area, denial of entry, evacuation, or sheltering-in-place.
- Tactical control objectives include preventing further injury and controlling or containing the spread of the hazardous material.
- Response objectives should be measurable, flexible, and time sensitive; they should also be based on the chosen strategy.
- Defensive actions include diking and damming, absorbing or adsorbing the hazardous material, stopping the flow remotely from a valve or shut-off, diluting or diverting the material, and suppressing or dispersing vapors.
- The decision to take action at a hazardous materials/WMD incident should be based on the concept of risk versus benefit.
- The type of personal protective equipment required for an incident depends on the material involved, any specific hazards, the physical state of the material, and the tasks to be performed by the operations level responder.
- The selection and use of chemical-protective clothing may have the greatest direct impact on responder health and safety.
- The EPA defines four levels of personal protective equipment: Level A (highest level of protection), Level B, Level C, and Level D (lowest level of protection).
- NFPA 1994, *Standard on Protective Ensembles for First Responders to CBRN Terrorism Incidents,* was developed to address the performance of protective ensembles specific to weapons of mass destruction. It covers three classes of garments: Class 2, Class 3, and Class 4.
- Respiratory protection is so important that it can be viewed as the defining element of personal protective equipment.
- Medical surveillance is the cornerstone of an effective health and safety management system for responders.
- Even though there should be no intentional contact with the hazardous material involved, a procedure or a plan must be established at every hazardous weapons/WMD incident to decontaminate anyone who accidentally becomes contaminated.
- Before any personal protective equipment is worn, hazardous materials response personnel should be aware of the physiological stress those garments create.

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# Wrap-Up

## 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.

CBRN Chemical, biological, radiological, and nuclear.

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

Closed-circuit self-contained breathing apparatus Self-contained breathing apparatus designed to recycle the user's exhaled air. This system removes carbon dioxide and generates fresh oxygen.

Contamination The process of transferring a hazardous material from its source to people, animals, the environment, or equipment all of which may act as a carriers for the material.

Control zones Areas at a hazardous materials incident that are designated as hot, warm, or cold, based on their safety and the degree of hazard found there.

Decontamination The physical and/or chemical process of reducing and preventing the spread of contaminants from people, animals, the environment, or equipment involved at hazardous materials/weapons of mass destruction incidents.

Decontamination corridor A controlled area within the warm zone where decontamination takes place.

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.

Denial of entry A policy under which, once the perimeter around a release site has been identified and marked out, responders limit access to all but essential personnel.

Emergency decontamination The process of removing the bulk of contaminants off a victim without regard for containment. It is used in potentially life-threatening situations, without the formal establishment of a decontamination corridor.

Evacuation The removal or relocation of those individuals who may be affected by an approaching release of a hazardous material.

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.

Immediately dangerous to life and health (IDLH) The atmospheric concentration of any toxic, corrosive, or asphyxiant substance such that it poses an immediate threat to life or could cause irreversible or delayed adverse health effects.

Isolation of the hazard area Steps taken to identify a perimeter around a contaminated atmosphere. Isolating an area is driven largely by the nature of the released

chemicals and the environmental conditions that exist at the time of the release.

Level A ensemble Personal protective equipment that provides protection against vapors, gases, mists, and even dusts. The highest level of protection, Level A 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 kind 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 respiratory protection.

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.

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.

Permissible exposure limit (PEL) The established standard limit of exposure to a hazardous material. It is based on the maximum time-weighted concentration at which 95 percent of exposed, healthy adults suffer no adverse effects over a 40-hour workweek.

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.

Recommended exposure level (REL) A value established by NIOSH that is comparable to OSHA's permissible exposure limit (PEL) and the threshold limit value/time-weighted average (TLV/TWA). The REL measures the maximum, time-weighted concentration of material to which 95 percent of healthy adults can be exposed without suffering any adverse effects over a 40-hour workweek.

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# Wrap-Up

Secondary contamination The process by which a contaminant is carried out of the hot zone and contaminates people, animals, the environment, or equipment. Also referred to as cross-contamination.

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

Sheltering-in-place A method of safeguarding people located near or in a hazardous area by keeping them in a safe atmosphere, usually inside structures.

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).

Threshold limit value (TLV) The point at which a hazardous material or weapon of mass destruction begins to affect a person.

Threshold limit value/ceiling (TLV/C) The maximum concentration of hazardous material to which a worker should not be exposed, even for an instant.

Threshold limit value/short-term exposure limit (TLV/STEL) The maximum concentration of hazardous material to which a worker can sustain a 15-minute exposure not more than four times daily without experiencing irritation or chronic or irreversible tissue damage. There should be a minimum one-hour rest period between any exposures to this concentration of the material. The lower the TLV/STEL value, the more toxic the substance.

Threshold limit value/skin The concentration at which direct or airborne contact with a material could result in possible and significant exposure from absorption through the skin, mucous membranes, and eyes.

Threshold limit value/time-weighted average (TLV/TWA) The airborne concentration of a material to which a worker can be exposed for 8 hours a day, 40 hours a week, and not suffer any ill effects.

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*

It is 9:00 A.M. when your crew is dispatched to a potential chemical spill at a nearby semiconductor manufacturing facility. Upon your arrival, the incident commander (IC) of the site emergency response team reports that a worker intentionally mixed sodium cyanide and sulfuric acid in a large container in an isolated 20′ × 20′ storage room. The IC gives you a handwritten note from the distraught worker, indicating that the chemical release was an apparent suicide attempt. There is a security camera monitoring the room, and the IC tells you it is clear that the worker is on the floor next to the bucket, not moving. The entire building has been evacuated. The IC urges you to make an immediate rescue. The IC hands you two MSDS—one for sodium cyanide and one for 97 percent sulfuric acid.

1. After reading the MSDSs for both chemicals, you realize the mixture of these two chemicals liberates cyanide gas, which is toxic by all routes of entry. Based on this information, which of the following actions would you take?
   - **A.** Take no action that requires entering the storage room. Call for additional resources including law enforcement and a hazardous materials/WMD team.
   - **B.** Don full structural turnout gear without an SCBA and enter the storage area to attempt a rescue.
   - **C.** Instruct a crew member to break out the rear window of the storage room, and then attempt a rescue wearing full turnout gear and SCBA.
   - **D.** Turn on the ventilation system to the entire building.
2. To safely enter the storage room to assess the worker, which level of protection would you choose to wear?
   - **A.** Level A
   - **B.** Level B
   - **C.** Level C
   - **D.** Level D
3. A Level A ensemble offers full body protection from highly contaminated environments and requires air-supplied respiratory protection such as SCBA. Which of the NFPA standards spells out the performance requirements for these types of garments, which are more correctly referred to as a vapor-protective ensemble?
   - **A.** NFPA 1994
   - **B.** NFPA 1992
   - **C.** NFPA 1991
   - **D.** NFPA 473
4. Level B ensembles are recommended when the type and atmospheric concentration of a released substance requires a high level of respiratory protection, but less skin protection. Which of the following items is the defining piece of equipment for a Level B ensemble?
   - **A.** Air-purifying respirator
   - **B.** Tyvek-Saranex chemical-protective garment
   - **C.** Butyl rubber gloves
   - **D.** Self-contained breathing apparatus or supplied-air respirator

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CHAPTER

# 5

## NFPA 472 Standard

### Competencies for Awareness Level Personnel

**4.4.2 Initiating the Notification Process.** Given scenarios involving hazardous materials/WMD incidents, awareness level personnel shall identify the initial notifications to be made and how to make them, consistent with the emergency response plan and/or standard operating procedures. [p. 111–112]

### Core Competencies for Operations Level Responders

**5.1.2.2** When responding to hazardous materials/WMD incidents, operations level responders shall be able to perform the following tasks:

(1) Analyze a hazardous materials/WMD incident to determine the scope of the problem and potential outcomes by completing the following tasks:
   (a) Survey a hazardous materials/WMD incident to identify the containers and materials involved, determine whether hazardous materials/WMD have been released, and evaluate the surrounding conditions.
   (b) Collect hazard and response information from MSDS; CHEMTREC/CANUTEC/SETIQ; local, state, and federal authorities; and shipper/manufacturer contacts.
   (c) Predict the likely behavior of a hazardous material/WMD and its container.
   (d) Estimate the potential harm at a hazardous materials/WMD incident.

(2) Plan an initial response to a hazardous materials/WMD incident within the capabilities and competencies of available personnel and personal protective equipment by completing the following tasks:
   (a) Describe the response objectives for the hazardous materials/WMD incident.
   (b) Describe the response options available for each objective.
   (c) Determine whether the personal protective equipment provided is appropriate for implementing each option.
   (d) Describe emergency decontamination procedures.
   (e) Develop a plan of action, including safety considerations.

(3) Implement the planned response for a hazardous materials/WMD incident to favorably change the outcomes consistent with the emergency response plan and/or standard operating procedures by completing the following tasks:
   (a) Establish and enforce scene control procedures, including control zones, emergency decontamination, and communications. [p. 111–115]
   (b) Where criminal or terrorist acts are suspected, establish means of evidence preservation. [p. 119]
   (c) Initiate an incident command system (ICS) for hazardous materials/WMD incidents. [p. 120–127]
   (d) Perform tasks assigned as identified in the incident action plan. [p. 120–127]
   (e) Demonstrate emergency decontamination. [p. 115]

(4) Evaluate the progress of the actions taken at a hazardous materials/WMD incident to ensure that the response objectives are being met safely, effectively, and efficiently by completing the following tasks:
   (a) Evaluate the status of the actions taken in accomplishing the response objectives. [p. 118–119]
   (b) Communicate the status of the planned response. [p. 118–119]

**5.4 Core Competencies—Implementing the Planned Response.**

**5.4.1 Establishing and Enforcing Scene Control Procedures.** Given two scenarios involving hazardous materials/WMD incidents, the operations level responder shall identify how to establish and enforce scene control, including control zones and emergency decontamination, and communications between responders and to the public and shall meet the following requirements:

(1) Identify the procedures for establishing scene control through control zones. [p. 112–115]

(2) Identify the criteria for determining the locations of the control zones at hazardous materials/WMD incidents. [p. 112–115]

(3) Identify the basic techniques for the following protective actions at hazardous materials/WMD incidents:
   (a) Evacuation [p. 116–117]
   (b) Sheltering-in-place [p. 117]

(4) Demonstrate the ability to perform emergency decontamination. [p. 115]

(5) Identify the items to be considered in a safety briefing prior to allowing personnel to work at the following:
   (a) Hazardous material incidents [p. 118–119]
   (b) Hazardous materials/WMD incidents involving criminal activities [p. 119]

(6) Identify the procedures for ensuring coordinated communication between responders and to the public. [p. 118–119]

**5.4.2 Preserving Evidence.** Given two scenarios involving hazardous materials/WMD incidents, the operations level responder shall describe the process to preserve evidence as listed in the emergency response plan and/or standard operating procedures. [p. 119]

**5.4.3 Initiating the Incident Command System.** Given scenarios involving hazardous materials/WMD incidents, the

operations level responder shall initiate the incident command system specified in the emergency response plan and/or standard operating procedures and shall meet the following requirements:

(1) Identify the role of the operations level responder during hazardous materials/WMD incidents as specified in the emergency response plan and/or standard operating procedures. [p. 126–127]

(2) Identify the levels of hazardous materials/WMD incidents as defined in the emergency response plan. [p. 126–127]

(3) Identify the purpose, need, benefits, and elements of the incident command system for hazardous materials/WMD incidents. [p. 120–127]

(4) Identify the duties and responsibilities of the following functions within the incident management system:

(a) Incident safety officer [p. 123]

(b) Hazardous materials branch or group [p. 124–125]

(5) Identify the considerations for determining the location of the incident command post for a hazardous materials/WMD incident. [p. 122]

(6) Identify the procedures for requesting additional resources at a hazardous materials/WMD incident. [p. 125]

(7) Describe the role and response objectives of other agencies that respond to hazardous materials/WMD incidents. [p. 120–127]

**5.4.4 Using Personal Protective Equipment.** The operations level responder shall describe considerations for the use of personal protective equipment provided by the AHJ, and shall meet the following requirements:

(1) Identify the importance of the buddy system. [p. 116]

(2) Identify the importance of the backup personnel. [p. 116]

(3) Identify the safety precautions to be observed when approaching and working at hazardous materials/WMD incidents. [p. 112–120]

(4) Identify the signs and symptoms of heat and cold stress and procedures for their control. [p. 119–120]

(5) Identify the capabilities and limitations of personnel working in the personal protective equipment provided by the AHJ. [p. 119–120]

(6) Identify the procedures for cleaning, disinfecting, and inspecting personal protective equipment provided by the AHJ.

(7) Describe the maintenance, testing, inspection, and storage procedures for personal protective equipment provided by the AHJ according to the manufacturer's specifications and recommendations.

**5.5 Core Competencies—Evaluating Progress.**

**5.5.1 Evaluating the Status of Planned Response.** Given two scenarios involving hazardous materials/WMD incidents, including the incident action plan, the operations level responder shall evaluate the status of the actions taken in accomplishing the response objectives and shall meet the following requirements:

(1) Identify the considerations for evaluating whether actions taken were effective in accomplishing the objectives. [p. 118–119]

(2) Describe the circumstances under which it would be prudent to withdraw from a hazardous materials/WMD incident. [p. 118–119]

**5.5.2 Communicating the Status of the Planned Response.** Given two scenarios involving hazardous materials/WMD incidents, including the incident action plan, the operations level responder shall communicate the status of the planned response through the normal chain of command and shall meet the following requirements:

(1) Identify the methods for communicating the status of the planned response through the normal chain of command. [p. 118–119]

(2) Identify the methods for immediate notification of the incident commander and other response personnel about critical emergency conditions at the incident. [p. 118–119]

## Knowledge Objectives

After studying this chapter, you will be able to:

- Describe how to notify the proper authorities and request additional resources.
- Describe the procedures for requesting additional resources.
- Describe scene control procedures using control zones.
- Describe appropriate locations for control zones and incident command posts.
- Describe effective coordinated communication techniques.
- Describe evidence preservation.
- Describe the role of the operations level responder, the incident safety officer, and a hazardous materials branch or group, at a hazardous materials incident.
- Describe levels of hazardous materials incidents.
- Describe the incident command system.
- Describe the importance of the buddy system and backup personnel.
- Describe protective actions during search and rescue, evacuation, and sheltering-in-place.
- Describe the safety precautions to be observed, including safety briefings, as well as physical capability requirements, including those for heat and cold stress, when approaching or working in a hazardous materials environment.
- Describe evaluation and communication of the status of the response.

## Skills Objectives

After studying this chapter, you will be able to:

- Establish scene control procedures.
- Establish evidence preservation.
- Initiate an incident command system.
- Perform tasks according to the incident action plan.
- Perform emergency decontamination.
- Evaluate and communicate progress in accomplishing the response objectives.

## You Are the Responder

Local law enforcement is requesting a response from the fire department. The initial report describes a suspicious package leaking a liquid. The package is located in a small storeroom on the ground floor of a three-story office building. While en route, the dispatcher announces this update: "Engine 40, be advised that police officers on scene are reporting several people complaining of eye irritation and nausea. There are also reports of an unusual odor being reported on the second and third floors. A full building evacuation is in progress."

1. Based on the initial reports, how would you go about taking control of the scene?
2. Working with the law enforcement agency on scene is important. Which steps would you take to facilitate a coordinated approach to managing and jointly commanding this incident?
3. Do you have the capabilities to communicate with other public safety agencies (various law enforcement agencies, for example)?

## Introduction

Scene control is important at all emergencies. At a hazardous materials incident, however, scene control is paramount because it affects both scene security and personnel accountability. Typically, the starting point for implementing any response is incident size-up and scene control. Size-up is the rapid mental process of evaluating the critical visual indicators of the incident (what's happening now), processing that information based on your training and experience, and arriving at a conclusion that will serve as the basis to form and implement a plan of action. Sometimes that plan includes an aggressive offensive posture—that is, attack the problem. In other cases, a defensive posture is appropriate—that is, isolate the scene, protect exposures, and allow the incident to stabilize on its own. The posture chosen should be driven by prudent decisions based on an accurate size-up and by your level of training. *Awareness level personnel are not required or expected to take offensive actions under the 2008 edition of NFPA 472, Standard for Competence of Responders to Hazardous Materials/Weapons of Mass Destruction Incidents, as they are not considered to be responders.* In many cases, the initial size-up is completed within a minute or two—or even sooner.

Size-up is always a work in progress. In other words, as the incident progresses, everyone on the scene should be constantly sizing up his or her own piece of the problem. All responders should maintain good situational awareness (SA) and understand the actions they are taking. Remember that responder safety is the number one priority.

The initial actions taken set the tone for the response and are critical to the overall success of the effort. The following lists give some examples of initial steps that awareness or operations level responders may take when implementing a response. These actions are based on the acronym SIN: Safety, Isolate, and Notify. Thinking about the basic actions represented by this mnemonic is a good starting point for a hazardous materials response, but remember—these are not absolute actions. Emergencies are seldom black-and-white problems; more typically, they involve many shades of gray that require you to *think*. It is always essential that you understand your job and know how to use the tools at your disposal both effectively and appropriately.

### Responder Tips

Think before you take action or give a command to others to take action. Do not put yourself or others at undue risk or become part of the problem. Your safety is the number one priority!

### Responder Safety Tips

Situational awareness) refers to the degree of accuracy by which one's perception of the current environment mirrors reality. In essence, SA is the act of processing all the information available to you, and understanding how it fits together in the big scheme of things.

## Safety

- Ensure your own safety—stay upwind, uphill, and out of the problem.
- Obtain a briefing from those involved in the incident prior to taking action (these individuals may include bystanders, facility representatives, or other responders).
- Understand the nature of the problem and the factors influencing the release.
- Attempt to make a positive identification of the released substance. If possible, obtain a material safety data sheet (MSDS), shipping papers, or United Nations/Hazardous Materials Code (UN/NA) identification of the substance.

## Isolate

- Isolate and deny entry to the scene.
- Recognize that your first priority is to separate the people from the problem—life safety is always the first consideration.
- Establish a command post in an area where you are protected from the incident and the weather, and where you have access to communications and technical reference materials.
- Determine your response objectives, choose a strategy (offensive or defensive, for example), and begin to formulate an incident action plan. This plan must be carried out as safely as possible and should be well thought out.
- Begin assigning tasks based on your initial assessment and strategic goals. Start thinking about how to match up the number of jobs with the number of available responders.

## Notify

- Decide whether you need to notify anyone else—for example, specialized responders, law enforcement, or other technical experts. You may also have to notify regulatory agencies such as the local fish and game agency; state office of emergency services, or county-level agencies such as an air quality control board. Have a current and comprehensive contact list of local, state, and federal resources available, and understand who the key players are in your authority having jurisdiction (AHJ). Large-scale incidents usually draw upon the resources of a large number of agencies.

Figure 5-1 ▸ illustrates a decision-making algorithm for a hazardous materials incident. Use it as a loose guide for developing an action plan and to focus your thinking.

**Responder Tips**

Do not let pressure from incoming units push you to make hasty decisions or assignments. Take time to think and formulate a plan of attack.

# Response Safety Procedures

Isolation of the release area is one of the first measures that awareness level personnel and operations level responders should implement. This goal is accomplished by establishing control zones and preventing anyone from entering the scene Figure 5-2 ▸. Both awareness level personnel and operations level responders should be capable of taking steps to control access to an incident. For example, access to the scene may be controlled by stretching banner tape across roads to divert traffic away from a spill or by preventing civilians or other responders from entering or reentering a contaminated building or approaching a rolled-over cargo tank. Scene control actions may require a coordinated effort between fire, police, EMS, and other agencies. *Be careful, however, that you don't mark off more real estate than you can control!*

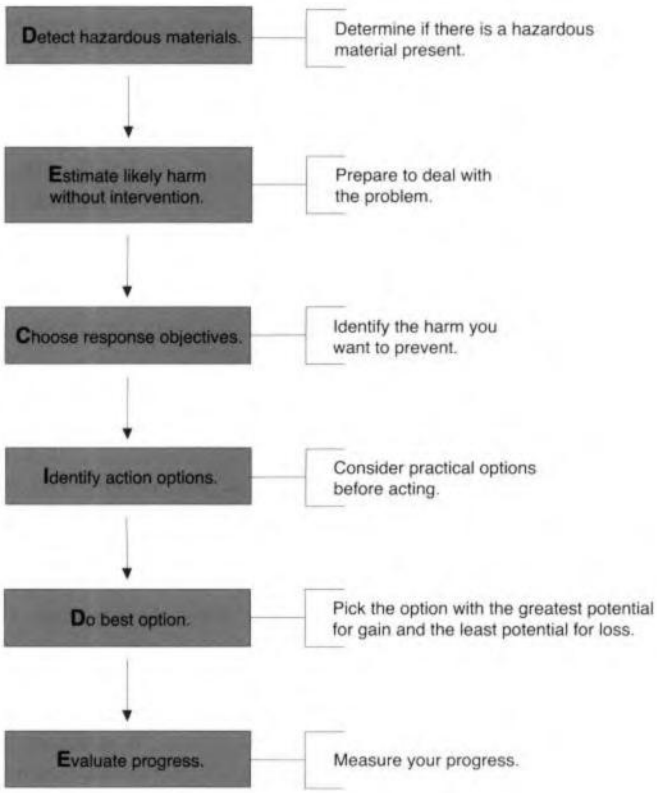
Responders may also find it useful to consult the *Emergency Response Guidebook* (ERG) for guidance on protective actions or as a starting point for gathering information about a released substance. Other initial actions may include evacuating others from the immediate area, implementing a sheltering-in-place strategy, rendering emergency medical care in a safe location away from the release, and surveying the scene to detect the presence of a hazardous material/WMD.

These basic protective actions should be taken immediately, while maintaining your own safety. For the first several minutes, not even the first responders themselves should enter the area. During this period, awareness level personnel, or responders trained to the operations level, can begin to gather necessary scene information and take initial steps to identify the materials involved. Again, these measures should be completed from a safe distance. Any actions taken should follow the predetermined local response plan or your agency's response guidelines.

Another important initial action might consist of identifying and securing any possible ignition sources—especially when the incident involves the release of flammable materials. So as not to create an unintentional ignition source, responders should use only radios and other electrical devices that have been certified as intrinsically safe Figure 5-3 ▸. With intrinsically safe electrical devices, the thermal and electrical energy within the device always remains low enough that a flammable atmosphere could not be ignited. Typically, a portable radio that is certified to be intrinsically safe must be specifically wired and used in conjunction with an intrinsically safe battery.

## Establishing Control Zones

Managing a hazardous materials incident by setting control zones and limiting access to the incident site helps reduce the number of civilians and public service personnel who may be exposed to the released substance. Control zones are established at a hazardous materials incident based on the chemical and physical properties of the released material, the environmental factors at the time of the release, and the general layout of the scene. Of course, isolating a city block in the busy downtown area of a large city presents far different challenges than isolating the area around a rolled-over cargo tank on an inter-




The DECIDE model, created by Ludwig Benner in the 1970's is designed to help responders think through a hazmat situation. The DECIDE acronym represents key decision making points that occur during a typical hazmat emergency. The model provides a guide for responders to follow in order to understand and update predictions of what's going to happen next, and to see how their actions are changing the course of the incident. The beauty of the DECIDE process is this: even when you don't know what will happen next, you can pinpoint the data gaps that will ultimately allow you to make a prediction.

**Figure 5-1** The DECIDE model. Reproduced with permission from Ludwig Benner.

state highway. Each situation is different, requiring you to be flexible and thoughtful about how you secure the area. Securing access to the incident helps ensure that responders arriving after the first-due units will not accidentally enter a contaminated area.

**Figure 5-2** Isolating the area of the release is a vital step in gaining control of the incident.

If the incident takes place inside a structure, the best place to control access is at the normal points of ingress and egress—doors. Once the doors are secured so that no unauthorized personnel can enter, appropriately trained emergency response crews can begin to isolate other areas as appropriate.

The same concept applies to outdoor incidents. The goal is to secure logical access points around the hazard. Begin by controlling intersections, on/off ramps, service roads, or other

**Figure 5-3** All intrinsically safe radios and batteries will be marked by the factory with a specific label denoting them as such.

access routes to the scene. Police officers should assist by diverting traffic at a safe distance outside the hazard area. They should block off streets, close intersections, or redirect traffic as needed.

During a long-term incident, highway department or public works department employees may be called upon to set up traffic barriers. Whatever methods or devices are used to restrict access, they should not limit or prevent a rapid withdrawal from the area by personnel working inside the hot zone.

It is not uncommon to set large control zones at the onset of an incident, only to discover that the zones may have been established too liberally. At the same time, control zones should not be defined too narrowly Figure 5-4. As the incident commander (IC) gets more information about the specifics of the chemical or material involved, the control zones may be changed. Ideally, the control zones will be established in the right place, geographically, the first time. Nevertheless, you should be prepared to expand or contract them if necessary. Wind shifts are a common reason why control zones are modified during the incident. If there is a prevailing wind pattern in your area, factor that consideration into your decision making when it comes to control zones.

Typically, control zones at hazardous materials incidents are labeled as *hot, warm,* or *cold*. You may also discover that other terms are used, such as *exclusionary zone* (hot zone), *contamination reduction zone* (warm zone), or *outer perimeter* (cold zone). In any case, make sure you understand the terminology used in your jurisdiction. Be prepared to discover that different jurisdictions may use terminology and setup procedures unlike the ones used in your agency. As long as you understand the concepts behind the actions and remember that safety is the main focus, the act of setting up and naming your zones can remain flexible. Avoid confusion by performing regular and consistent training, and making sure all responders are on the same page with the terminology.

The hot zone is the area immediately surrounding the release, which is also the most contaminated area. All personnel working in the hot zone must wear complete, appropriate protective clothing and equipment. Its boundaries should be set large enough that adverse effects from the released substance will not affect people outside of the hot zone. An incident involving a gaseous substance or a vapor, for example, may require a larger hot zone than one involving a solid or nonvolatile liquid leak. In some cases, atmospheric monitoring, plume modeling, or reference sources such as the *ERG* may prove useful in helping to establish the parameters of a hot zone. Specially trained responders, in accordance with their level of training, should be tasked with using these tools. Keep in mind that the physical characteristics of the released substance will significantly affect the size and layout of the hot zone. Additionally, all responders entering the hot zone should avoid contact with the product to the greatest extent possible—an important goal that should be clearly understood by those entering the hot zone. Adhering to this policy makes the job of decontamination easier and reduces the risk of secondary contamination.

Personnel accountability is important, so access into the hot zone must be limited to only those persons necessary to control the incident. All personnel and equipment must be decontaminated when they leave the hot zone. This practice ensures that contamination is not inadvertently spread to "clean" areas of the scene.

The warm zone is where personnel and equipment transition into and out of the hot zone. It contains control points for access to the hot zone as well as the decontamination corridor. Only the minimal amount of personnel and equipment necessary to perform decontamination, or support those operating in the hot zone, should be permitted in the warm zone.

Generally, personnel working in the warm zone can use personal protective equipment (PPE) whose protection is rated one level lower than that of the PPE used in the hot zone. For example, if personnel in the hot zone are wearing Level A ensemble, personnel in the warm zone should dress in at least Level B ensemble. This recommendation is not a hard-and-fast rule, however. You must understand the hazard well enough to make that determination on a case-by-case basis.

Beyond the warm zone is the cold zone. The cold zone is a safe area where personnel do not need to wear any special protective clothing for safe operation. Personnel staging, the

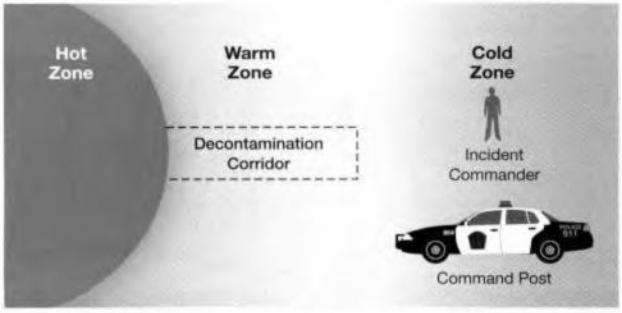



Figure 5-4 Control zones spread outward from the center of a hazardous materials incident.

### Responder Tips

It is always easier and safer to *reduce* the size of the control zones than to *enlarge* them.

### Responder Tips

The primary functions of warm zone activities are decontamination and providing ready support to personnel operating in the hot zone.

### Responder Safety Tips

The control zones shown in Figure 5-4 are circular and well defined. In real life, they seldom follow such an orderly fashion.

command post, EMS providers, and the area for medical monitoring, support, and/or treatment after decontamination are all located in the cold zone. Typically, support personnel for the incident operate in this area.

## Performing Emergency Decontamination

As discussed in Chapter 4, at every hazardous materials incident there must be a plan in place to decontaminate any responder who accidently becomes contaminated. Victims who are removed from a contaminated zone must also be decontaminated by personnel who have donned the appropriate protective gear and who have been trained in the proper methods of victim decontamination. Emergency decontamination is the process of getting the bulk of contaminants off a person as quickly and completely as possible. Emergency decontamination is used in potentially life-threatening situations, without the formal establishment of a decontamination corridor. To perform emergency decontamination, follow the steps in Skill Drill 5-1:

1. Ensure that you have the appropriate PPE to protect against the chemical threat.
2. Stay clear of the product, and do not make physical contact with it.
3. Make an effort to contain runoff by directing victims out of the hazard zone and into a suitable location for decontamination.
4. Instruct or assist victims in removing contaminated clothing. (Step 1)
5. Rinse victims with copious amounts of water. Avoid using water that is too warm or too cold; room-temperature water is best. (Step 2)
6. Provide or obtain medical treatment for victims, and arrange for their transport.

## Protective Actions

Evaluating the threat to life is the number one response priority at a hazardous materials incident. The safety of the responders is always taken into account, but the bottom line is this: If there is no life threat—either immediate or anticipated—the severity of the incident is diminished. This is not to say that property or the environment is unimportant. Rather, it is simply an acknowledgment that you as a responder must consider the threat to life before anything else.

Life-safety actions include ensuring your own safety and searching for, and possibly rescuing, those persons who were

NFPA 472, 5.1.2.2, 5.4.1

### Skill Drill 5-1

### Performing an Emergency Decontamination

1 Ensure that you have the appropriate PPE. Stay clear of the product, and do not make physical contact with it. Make an effort to contain runoff. Instruct or assist victims in removing contaminated clothing.

2 Rinse victims with copious amounts of water. Avoid using water that is too warm or too cold; room-temperature water is best.

Figure 5-5 The IC must weigh the severity of the threat to responders against the possibility of saving anyone before authorizing an interior search.

immediately exposed to the substance or those who may now be in harm's way. For example, an IC might be faced with a decision of whether to evacuate people ahead of an advancing vapor cloud or when an explosive device is discovered. This is not an easy decision, as efforts to relocate people bring up many complications. A risk-based method of decision making should be employed in such cases. Essentially, the IC should weigh the severity of the threat against the potential impact of moving people from one location to another Figure 5-5. Evacuating a predominately ill and elderly population from a care facility, for example, may take a long time, have negative effects on the evacuees, and require a lot of resources. Given these concerns, the IC must decide if the hazard merits such a move or if other methods might be used to protect this type of population.

## The Buddy System and Backup Personnel

It is *not* an accepted practice at a hazardous materials emergency to allow just one responder to don a PPE ensemble and enter a contaminated environment alone. The risks of something going wrong are too great; operating alone should *never* be allowed. To that end, it is an accepted practice to implement the buddy system for those personnel entering contaminated areas. The simplest expression of the buddy system is for no fewer than two responders to enter a contaminated area. This practice should not be deviated from under any circumstance. The use of the buddy system is so important; in fact, it is required by the OSHA HAZWOPER regulation. It is the responsibility of the IC to not only limit the number of responders working in the contaminated area, but also to prevent responders from working alone. More than two responders might enter a contaminated area, but never fewer than two. To work alone is to take an undue risk!

On a hazardous materials incident, a backup team—that is, backup personnel, typically wearing the same level of protection as the initial entry team—provides another layer of safety for those entering the high-contamination areas. Like the use of the buddy system, the use of backup personnel is required by the OSHA HAZWOPER regulation. The backup team could be called upon to remove those individuals working in the hot zone if an emergency occurs and the entry crew members are unable to escape on their own. The concept is much like the practice of establishing a rapid intervention team at a structure fire. Backup personnel must be in place and ready to spring into action whenever personnel are operating in the hot zone.

All personnel must be briefed before approaching the hazard area or entering the hot zone. To reiterate, no one should enter the hot zone alone; at least two team members should suit up and enter together, and at least two additional team members should suit up and stand by to assist those who entered first. The IC should ensure that backup personnel are prepared for immediate entry into the hot zone. Team members should always remain within visual or radio contact with one another and with someone outside of the hot zone.

## Evacuation

The IC must consider many factors before making decisions concerning evacuation. Some of those factors include considering the nature and duration of the release; the nature of the evacuees, such as their age, underlying health status, and mobility; the ability to support the evacuees with basic services such as food, water, and shelter; and transportation challenges. When considering evacuating a significantly large group of people, it may be helpful to consider the host of "shuns" associated with the task. The "shuns" is a word play on the ending of all of the following terms:

- Contamination (the trigger for the evacuation)
- Communication
- Transportation
- Nutrition
- Sanitation
- Habitation
- Compassion

You may identify more "shuns" that are specific to your AHJ—be creative and complete when thinking about evacuation.

Once the evacuation order is given, fire fighters and law enforcement personnel may be called upon to assist in the physical relocation of residents to a safe area. Their work may include such actions as traveling to homes and informing residents that they must relocate to a temporary shelter.

Before an evacuation order is given, a safe area with suitable facilities should be established. In many cases, schools, fairgrounds, and sports arenas are used as shelters. The evacuation area should be located close enough to the exposure for the evacuation to be practical, but far enough away from the incident to be safe. Depending on the time of day and the season, it may take a considerable amount of time to evacuate even a small residential area. Temporary evacuation areas may

**Responder Tips**

Evacuation has some significant risks involved, even when the operation is properly planned. Think carefully and consider all options before proceeding with a full-scale evacuation.

**Responder Safety Tips**

When carrying out an evacuation, make provisions for protecting yourself in case the wind shifts or you unexpectedly come in contact with the hazardous material.

be needed to shelter residents until evacuation sites or structures indicated in your community's emergency response plan are open and accessible.

Transportation to temporary evacuation areas must be arranged for all populations when an evacuation is ordered. As part of this effort, the needs of the elderly, handicapped, and special needs persons should be considered. It would be a mistake to assume all evacuees are able to move on their own. Initial evacuation distances may be derived from the *ERG* Figure 5-6. Note that the *ERG* does not give complete detailed information for all conditions that responders might potentially encounter, such as weather extremes, road conditions, or actual conditions encountered at the scene.

The ability to evacuate an area and staff to an adequate emergency shelter will be determined by the local resources available. In severe weather, evacuation can be challenging at best. Even in perfect circumstances, evacuation of residents will be a process that is measured in hours, not minutes. Preplanning for evacuations is key to a safe and successful emergency evacuation.

**GUIDE 162** RADIOACTIVE MATERIALS (LOW TO MODERATE LEVEL RADIATION) ERG2008

**POTENTIAL HAZARDS**

**HEALTH**

- Radiation presents minimal risk to transport workers, emergency response personnel and the public during transportation accidents. Packaging durability increases as potential hazard of radioactive content increases.
- Undamaged packages are safe. Contents of damaged packages may cause higher external radiation exposure, or both external and internal radiation exposure if contents are released.
- Low radiation hazard when material is inside container. If material is released from package or bulk container, hazard will vary from low to moderate. Level of hazard will depend on the type and amount of radioactivity, the kind of material it is in, and/or the surfaces it is on.
- Some material may be released from packages during accidents of moderate severity but risks to people are not great.
- Released radioactive materials or contaminated objects usually will be visible if packaging fails.
- Some exclusive use shipments of bulk and packaged materials will not have "RADIOACTIVE" labels. Placards, markings and shipping papers provide identification.
- Some packages may have a "RADIOACTIVE" label and a second hazard label. The second hazard is usually greater than the radiation hazard; so follow this GUIDE as well as the response GUIDE for the second hazard class label.
- Some radioactive materials cannot be detected by commonly available instruments.
- Runoff from control of cargo fire may cause low-level pollution.

**FIRE OR EXPLOSION**

- Some of these materials may burn, but most do not ignite readily.
- Uranium and Thorium metal cuttings may ignite spontaneously if exposed to air (see GUIDE 136).
- Nitrates are oxidizers and may ignite other combustibles (see GUIDE 141).

**PUBLIC SAFETY**

- **CALL Emergency Response Telephone Number on Shipping Paper first. If Shipping Paper not available or no answer, refer to appropriate telephone number listed on the inside back cover.**
- **Priorities for rescue, life-saving, first aid, fire control and other hazards are higher than the priority for measuring radiation levels.**
- Radiation Authority must be notified of accident conditions. Radiation Authority is usually responsible for decisions about radiological consequences and closure of emergencies.
- As an immediate precautionary measure, isolate spill or leak area for at least 25 meters (75 feet) in all directions. • Stay upwind. • Keep unauthorized personnel away.
- Detain or isolate uninjured persons or equipment suspected to be contaminated; delay decontamination and cleanup until instructions are received from Radiation Authority.

**PROTECTIVE CLOTHING**

- Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide adequate protection.

**EVACUATION**

**Large Spill**

- Consider initial downwind evacuation for at least 100 meters (330 feet).

**Fire**

- When a large quantity of this material is involved in a major fire, consider an initial evacuation distance of 300 meters (1000 feet) in all directions.

*Page 270*

Figure 5-6 Evacuation distances for small spills or fires are listed in the orange-bordered pages of the ERG.

**Responder Safety Tips**

If you are wearing PPE to relocate people, you are no longer in evacuation mode—you are in rescue mode.

A good way for the IC to determine the area to be evacuated, including how far to extend actual evacuation distances, is to utilize detection and monitoring devices to identify areas of airborne contamination. These tools are discussed in Chapter 14, Mission-Specific Competencies: Air Monitoring and Sampling. Access to local weather conditions is invaluable in this decision-making process.

## Sheltering-in-Place

As discussed in Chapter 4, sheltering-in-place is a method of safeguarding people in a hazardous area by keeping them in an enclosed atmosphere, usually inside structures. Local emergency plans should identify local facilities where vulnerable populations might be found, such as schools, churches, hospitals, nursing homes, and apartment complexes. When residents are sheltered in place, they remain indoors with windows and doors closed. All ventilation systems are turned off to prevent outside air from being drawn into the structure.

The toxicity of the hazardous material and the amount of time available to avoid the oncoming threat are major factors in the decision whether to evacuate or to use a sheltering-in-place strategy. The expected duration of the incident is also a factor in determining whether sheltering-in-place is a viable option. The longer the incident, the more time the material has to enter or permeate into protected areas.

## Search and Rescue

Ensuring your safety is the first priority in any emergency response situation, and a hazardous materials incident is no exception. The search for and rescue of people involved in a hazardous materials event becomes more complicated in the setting of a hazardous materials incident. In a structure fire, search and rescue is done quickly to remove victims from the smoke-filled environment. In a hazardous materials incident, all emergency response personnel (fire, law enforcement, emergency medical services) must first recognize and identify the released substance. After this is accomplished, the IC should use a risk-based thought process to understand the hazards as they relate to the possibilities of an adverse outcome; only then may personnel be ordered to attempt search and rescue.

Ultimately, the IC must determine whether entry into the hot zone to perform search and rescue is a worthy endeavor. If the released substance is highly toxic, victims may not have survived the initial exposure to the material. If it is determined that a search can be safely performed, rescue teams wearing proper PPE may then enter the hot zone to look for or retrieve victims. The victims are removed to the warm zone, where they can be decontaminated and turned over to EMS providers for transport to a medical facility. See Chapter 12 of this text for more information on this topic.

## Safety Briefings

Typically, before significant actions are taken at a hazardous material incident, the IC should ensure that a *written* site safety plan is completed and a *verbal* safety briefing is performed. The written plan may be abandoned, however, and the verbal plan may be quite brief in the event a rescue is required. The purpose of the safety briefing is to inform (at a minimum) all responders of the health hazards that are known or anticipated, the incident objectives, emergency medical procedures, radio frequencies and emergency signals, a description of the site, and the PPE to be worn. Each authority having jurisdiction should develop templates for site safety plans and verbal safety briefings. The use of a standardized form means that the safety plan can be completed in a timely manner; standardized formats also keep safety briefings on track and provide a logical format that everyone can follow.

There are many ways to conduct a safety briefing. Chiefly, a good safety briefing should be carried out in the manner that its name implies—it should be brief. It should be complete enough to provide the responders on the scene with relevant information, yet not overly detailed with useless or "nice to know" information.

At small incidents where the incident management structure is simple, the IC may be responsible for both putting together a site safety plan and conducting the safety briefing. At larger incidents, where an incident safety officer (also referred to as a safety officer) or hazardous materials safety officer is appointed, it is the responsibility of that officer to participate in the preparation and implementation of the site safety plan. The roles of these officers are discussed in more detail later in this chapter. The depth and scope of the safety briefing should have a direct correlation with the severity and complexity of the incident. For significant incidents, where the released substances are highly toxic or where other significant health hazards are present, the site safety plan and briefing may be comprehensive and documented in writing.

The IC may establish predetermined trigger points, intended to evaluate the status of the planned response, that may lead to withdrawal of responders from the hot zone. Based on a lack of progress toward meeting the incident objectives, the IC may later decide to abandon the current plan of action and withdraw to a safe distance, set a defensive perimeter, and wait for the additional resources to arrive—or to allow the hazardous materials incident to run its course. Typically, these decisions are made when the offensive actions are not effective in mitigating the problem, the selected PPE is found to be incorrect or ineffective, the tools and equipment required to solve the problem are ineffective or unavailable, or the problem is simply too overwhelming to handle with the available resources. A reasonable and prudent IC knows when he or she is "outgunned" and does not make a foolhardy decision to risk the health and safety of the personnel. In the event a withdrawal is necessary, the IC should include evacuation signals in the pre-entry briefing.

It is also important, within the context of a safety briefing, to discuss incident communications. *It is common for communication to be disrupted or otherwise hampered during an emergency.*

Figure 5-7 It is important to use the communication tools provided to you. Pay attention and stay on the right channel!

To avoid undue communications complications, the IC may designate command and tactical channels for the incident. Entry teams may be instructed to communicate on a dedicated radio channel to ensure they are not cut off or excluded from making a critical radio transmission by other radio chatter. Radio transmissions are an excellent way to communicate the status of the mitigation efforts and to gauge the success or failures of those efforts Figure 5-7 ▲.

In the event that things are not going as planned, the entry team may contact the entry team leader, who may have a face-to-face conversation with the safety officer or hazardous materials safety officer (assistant safety officer). That conversation, carried out through the normal chain of command, may result in a change of tactics, modification of the incident objectives, or a complete abandonment of the effort. In any case, by observing the proper chain of command, all parties with management and safety interests at the scene will be included in the appropriate discussions. This approach will also help to ensure coordinated communication to the public.

In some jurisdictions, the safety officer conducts the majority of the safety briefing. In others, the IC or hazardous materials group supervisor conducts the safety briefing in conjunction with the safety officer. Regardless of how it's accomplished, a safety plan should be completed (and approved by the IC), and a safety briefing should be conducted before responders attempt to enter the incident site. Make sure that you

are familiar with and follow the standard operating procedures in your jurisdiction.

In today's world, the threat of terrorism or other incidents with criminal intent drives the need for complete and meaningful safety briefings. Briefings at these types of incidents may also include procedures for operating at a crime scene or evidence collection procedures. It is imperative to understand the needs of law enforcement, especially as those needs relate to beginning an investigation or collecting evidence for a possible prosecution. Operating at a crime scene can present a complicated set of circumstances, but a good working relationship between all agencies on the scene (ideally, established before the event) will create better operational efficiency during the response. Refer to the standard operating procedures and policies established by your agency to fully understand your role during a hazardous materials incident with a criminal intent.

A written safety plan should also include information about the heat or cold stress the responders may encounter while engaging in their work. Working in PPE in ideal conditions is challenging enough on its own. When temperature extremes are anticipated, their effects on the responders should be acknowledged and understood by everyone operating at the scene.

## Excessive-Heat Disorders

Hazardous materials responders operating in protective clothing should be aware of the signs and symptoms of heat exhaustion, heat stress, dehydration, and heat stroke. If the body is unable to disperse heat because an ensemble of PPE covers it, serious short- and long-term medical issues could result.

Heat exhaustion is a mild form of shock that arises when the circulatory system begins to fail because the body is unable to dissipate excessive heat and becomes overheated. With heat exhaustion, the body's core temperature rises, followed by weakness and sweating. A person suffering from heat exhaustion may become dizzy and have episodes of blurred vision. Other signs and symptoms of heat exhaustion include acute fatigue, headache, and muscle cramps. *Signs and symptoms may vary among individuals, however.* Any individual experiencing heat exhaustion should be removed at once from the heated environment, rehydrated with electrolyte solutions (perhaps by intravenous methods), and kept cool. If not properly treated, heat exhaustion may progress to a potentially fatal condition.

When treating heat-related illnesses, it is important to avoid pouring cold water or otherwise placing the victim in an unusually cold environment. The extreme swing in temperature may have adverse effects on the individual's recovery. Using tepid water for drinking and cooling the skin is the safest approach to take. Keep in mind that rehydration by mouth is much slower than rehydration by intravenous line.

Heat stroke is a severe and potentially fatal condition resulting from the failure of the temperature-regulating capacity of the body. It is caused by exposure to the sun or working in high temperatures. Reduction or cessation of sweating is an early symptom. The body temperature can rise to 105°F (40.5°C) or higher, and be accompanied by a rapid pulse; hot, red-looking skin; headache; confusion; unconsciousness; and possibly seizures. Heat stroke is a true medical emergency that requires immediate transport to a medical facility.

In an effort to combat heat stress while their personnel are 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 is designed to accomplish the same goal: to reduce the effects of heat stress on the human body. Chapter 7 of this text, Mission-Specific Competencies: Personal Protective Equipment, provides more information on the specific technologies used for cooling.

### Responder Safety Tips

Most heat-related illnesses are typically preceded by dehydration. It is important to stay hydrated so that you can function at your maximum capacity. As a frame of reference, athletes should consume approximately 500 mL of fluid (water) prior to an event and 200–300 mL at regular intervals. Responders can be considered occupational athletes—so keep up on your fluids!

## Cold-Temperature Exposures

Responders at hazardous materials incidents may be exposed to two types of cold temperatures: those caused by the released materials and those caused by the operating environment, including ambient air temperatures or conditions such as rain, snow, or other adverse cold-weather conditions. Hazardous materials such as liquefied gases and cryogenic liquids may expose responders to the same low-temperature hazards as those created by cold-weather environments. Exposure to severe cold for even a short period of time may cause severe injury to body surfaces, especially to the ears, nose, hands, and feet.

Two environmental factors in particular influence the extent of cold injuries: temperature and wind speed. Because still air is a poor heat conductor, responders working in low temperatures with little wind can endure these conditions for longer periods (assuming that their clothing remains dry). However, when low temperatures are combined with significant winds, wind chill occurs. As an example, if the temperature with no wind is 20°F (7°C), it will feel like –5°F (–21°C) when the wind speed is 15 miles per hour.

Regardless of the temperature, anyone will perspire while wearing chemical-protective clothing. When this wet inner clothing is removed during the decontamination process, particularly in a cold environment, the body will cool rapidly. Wet clothing extracts heat from the body as much as 240 times faster than dry clothing. It may also lead to hypothermia, a condition in which the core body temperature falls below 95°F (35°C). Hypothermia is a true medical emergency.

Responders must be aware of the dangers of frostbite, hypothermia, and impaired ability to work when temperatures are low or when they are working in wet clothing. All personnel should wear layered clothing and be able to warm themselves in heated shelters or vehicles.

Figure 5-8 Trenchfoot can result when wet socks are worn at long-term incidents in cool environments.

The layer of clothing next to the skin, especially the socks, should be kept dry. Trenchfoot can result when wet socks are worn at long-term incidents (lasting more than 12 hours) in cool (not cold) environments. The combination of cold and wet softens the skin, causing numbness, tingling, and, in some cases, peeling skin. Infection can result from trenchfoot Figure 5-8 ▲.

Responders should carefully schedule their work and rest periods and monitor their physical working conditions. For example, warm or cool shelters should be available where responders may don and doff their protective clothing.

## Personal Protective Equipment: Physical Capability Requirements

Medical monitoring is the on-scene evaluation of response personnel who may be experiencing adverse effects because they are wearing PPE or because they have been exposed to heat, cold, stress, or hazardous materials. The goal of medical monitoring is to quickly identify medical problems—while responders are on-scene—so they can be treated in a timely fashion, thereby preventing severe adverse effects and maintaining the optimal health and safety of on-scene personnel.

Responders should undergo pre-entry health screening prior to donning any level of chemical-protective equipment (this step may be eliminated in the event that rapid entry is required for rescue or other life-safety reasons). This screening should include a check of vital signs, including pulse rate, blood pressure, and respiratory rate. Body weight measurements and general health should also be observed. In the event the responder presents with an abnormal reading (determined by the AHJ), that responder may be excluded from wearing PPE or participating in the mitigation phase of the incident.

Once the mission is complete and the responder has been decontaminated and doffed the PPE, a second medical evaluation—similar to the initial evaluation—should be completed. In the event of abnormal findings (again determined by the AHJ), the responder may need to be seen by a physician or transported to an appropriate receiving hospital.

For a more comprehensive set of criteria for medical monitoring/support, consult NFPA 473, *Standard for Competencies for EMS Personnel Responding to Hazardous Materials/Weapons of Mass Destruction Incidents*.

## The Incident Command System

In the 1970s, a series of devastating wildland fires occurred in Southern California, requiring the services of numerous local and state resources. That rash of fires illustrated the need for a better way to manage large numbers of agencies and resources called to a major incident. Also as a result of those fires, many of the agencies involved agreed to form a working group, subsequently named FIRESCOPE (Fire Resources of Southern California Organized for Potential Emergencies). The FIRESCOPE group began its work by identifying several problem areas common to almost all major or complex incidents: ineffective communications; span-of-control challenges; a lack of a common command structure; the inability to track personnel working on the scene; and the inability to effectively coordinate on-scene resources.

### Responder Tips

*Span of control* refers to how many responders can be effectively managed by one supervisor. Typically, an acceptable ratio for emergency operations is one supervisor to five responders. This span of control is flexible and depends on issues such as the criticality of the mission or task being performed, the skill level of the supervisor, and the skill levels of the responders.

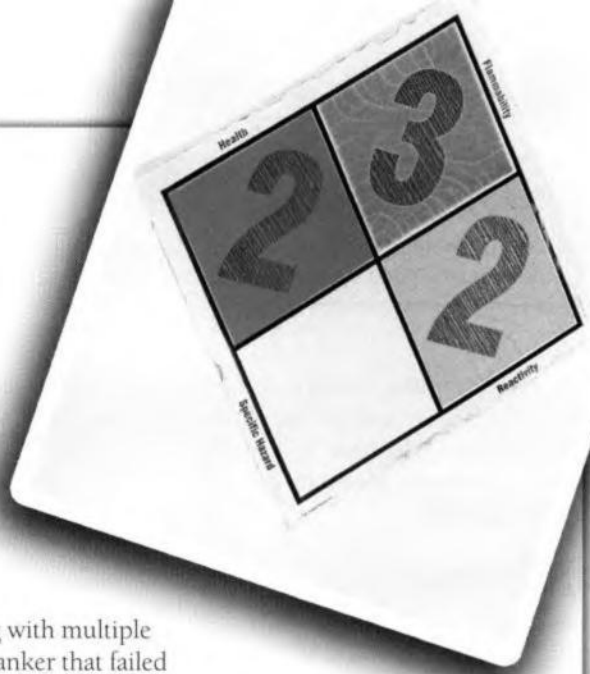
Subsequently, the FIRESCOPE consortium developed a standardized yet flexible management system called the incident command system (ICS). Some of the key benefits of using ICS are summarized here:

- Common terminology
- Consistent organizational structure
- Consistent position titles
- Common incident facilities

The ICS, which was originally designed for managing wildland fires, subsequently evolved into an all-risks management structure suitable for managing all types of fires, natural disasters, technical rescues, and any other type of emergency of virtually any size. When properly used, it provides a strong organizational framework to support the operational goals and objectives. The HAZWOPER OSHA regulation requires that the ICS be implemented in response to all hazardous materials incidents, including the use of a written incident action plan. Now more than ever, it's critical that all responders—regardless of the patch on their uniform or the nature of their job, or even their geographic location—understand the need for this cohesive emergency management tool.

The ICS can be expanded to handle an incident of any size and complexity. Hazardous materials incidents can be

# Voices *of* Experience




One spring morning at approximately 0900 hours, we responded, along with multiple other agencies, to a neighboring department for an overturned truck tanker that failed to negotiate a turn in the road. At the time of our response, it was unknown what type of chemical we were dealing with.

After I checked in with the incident commander, he assigned me as incident safety officer. Once we were in place, all operational individuals were briefed on the suspected chemical and its properties, along with the response plan. Our first responsibility was to verify the identity of the chemical involved. Next we established the hot, warm, and cold zones. A decontamination corridor was also established, with constant air monitoring.

An entry team, with backup teams in place, identified the damage to the truck tanker and the approximate amount of the chemical spilled. They also conducted diking and absorption activities in containing the spilled chemical.

Through the post-briefing of the entry team, it was determined that the safest and most efficient means to mitigate the situation would be to transfer the chemical to another truck tanker. The incident commander, along with the operations section chief, developed an incident action plan, and the incident was mitigated exactly as planned. Although this incident lasted approximately 15 hours and involved many agencies including private cleanup contractors, we were able to ensure life safety by establishing control zones, delegate tasks through use of the incident command system, and take protective actions such as conducting a safety briefing and utilizing backup teams. Remember to utilize all of your resources when dealing with a potential hazardous materials release.

Jeffry J. Harran
Lake Havasu City Fire Department
Lake Havasu City, Arizona

*"We were able to ensure life safety by establishing control zones, delegate tasks through use of the incident command system, and take protective actions such as conducting a safety briefing and utilizing backup teams."*

**Responder Tips**

The OSHA HAZWOPER regulations mandate the use of the incident command system at hazardous materials incidents.

extremely complex, such that local, state, and federal responders and agencies may all become involved in many cases of long duration. The basic ICS consists of five functions: command, operations, planning, logistics, and finance/administration Figure 5-9.

## Command

Command is established when the first unit arrives on the scene and is maintained until the last unit leaves the scene. Command is directly responsible for the following tasks:

- Determining strategy
- Selecting incident tactics
- Creating the action plan
- Developing the ICS organization
- Managing resources
- Coordinating resource activities
- Providing for scene safety
- Releasing information about the incident
- Coordinating with outside agencies

### Unified Command

When multiple agencies with overlapping jurisdictions or legal responsibilities are involved in the same incident, a unified command provides several advantages. Using this approach, representatives from various agencies cooperate to share command authority Figure 5-10.

### Incident Command Post

Regardless of whether there is a single incident command or the incident is run under a unified command, the command function is always located in an incident command post (ICP). The ICP is a location at or near the scene of the emergency where the IC is located and where coordination, control, and communications are centralized. Command and all direct support staff should be located at the ICP. Ideally, the ICP should be located in an area where it is not threatened by the incident.

During a hazardous materials incident, the ICP should be established uphill and upwind of the incident, keeping in mind the potential for predicted changes in wind direction based on the time of day.

Figure 5-10 A unified command involves many agencies directly involved in the decision-making process for a large incident.

### Command Staff

The incident commander (IC) is the person in charge of the entire incident and should be qualified to be in the position. The OSHA HAZWOPER regulations [1910.120(q)(6)(v)] state that an on-scene IC, who will assume control of the incident scene beyond the first-responder awareness level, should receive at least 24 hours of training equal to the first-responder operations level and, in addition, have competency in the following areas:

- Know and be able to implement the jurisdiction's incident command system.
- Know how to implement the jurisdiction's emergency response plan.
- Know and understand the hazards and risks associated with responders working in chemical-protective clothing.
- Know how to implement the local emergency response plan.
- Know about the state emergency response plan and the Federal Regional Response Team.
- Know and understand the importance of decontamination procedures.

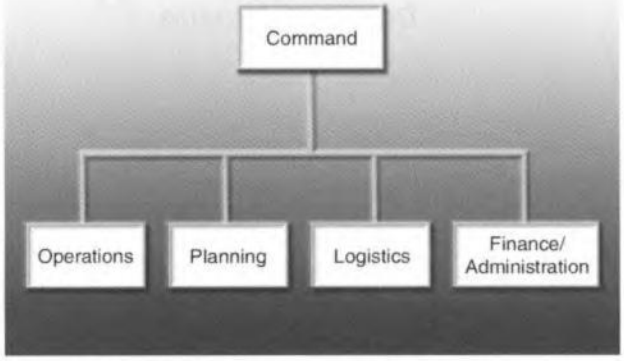



Figure 5-9 Major functional components of the ICS.

**Responder Safety Tips**

It is important to consider the prevailing winds of the area when establishing the location of the incident command post.

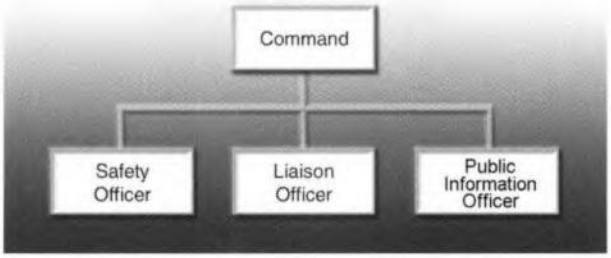



Figure 5-11 The command staff members report directly to the incident commander.

Figure 5-12 The public information officer is responsible for gathering and releasing incident information to the media and other appropriate agencies.

The command staff consists of the safety officer, the liaison officer, and the public information officer Figure 5-11. The IC and safety officer positions are required by OSHA during a hazardous materials response; the two positions cannot be filled by the same person. These job functions report directly to the IC and are critical to the effective management of a hazardous materials/WMD incident.

### *Safety Officer*

According to the OSHA HAZWOPER regulation (1910.120(q)(3)(vii)), the role of the safety officer at a hazardous materials incident is clear:

> The individual in charge of the ICS shall designate a safety officer, who is knowledgeable in the operations being implemented at the emergency response site, with specific responsibility to identify and evaluate hazards and to provide direction with respect to the safety of operations for the emergency at hand.

The OSHA HAZWOPER regulation, in 1910.120 (q)(3)(viii), goes on to describe the authority of the safety officer at a hazardous materials incident:

> When activities are judged by the safety officer to be an IDLH and/or to involve an imminent danger condition, the safety officer shall have the authority to alter, suspend, or terminate those activities. The safety official shall immediately inform the individual in charge of the ICS of any actions needed to be taken to correct these hazards at the emergency scene.

### *Liaison Officer*

The liaison officer is the point of contact for cooperating and assisting agencies on the scene. The basic distinction between a cooperating agency and an assisting agency relates to the financial stake each has in the management or outcome of the incident. Typically, if an agency has a financial responsibility for the incident, it is considered an assisting agency; all others are considered cooperating agencies. There is much gray area here, however, and you must follow your jurisdiction's direction of determining the distinction between an assisting and cooperating agency.

On a hazardous materials incident, the liaison officer deals with representatives from federal agencies, state and local resources, and any other outside agency with an interest in the management or outcome of the incident. Ideally, all of these representatives should have the authority to make decisions on behalf of the agency they represent. It is extraordinarily cumbersome to deal with an agency representative who must constantly go back to a key decision maker within his or her own organization to get approvals.

### *Public Information Officer*

The public information officer typically functions as a point of contact for the media or any other entity seeking information about the incident Figure 5-12. As with all of the other command staff positions, only one person should fill this role. Although many people may work with or for the public information officer, they should serve as assistants. This chain of command is necessary to streamline communications and reduce redundancies in the management system.

The value of the public information officer should not be underestimated. Keeping the media (and others) well informed is an important piece of the incident management objectives. A wise IC will acknowledge that fact and incorporate good media relations into the incident objectives.

## General Staff Functions

When the incident is too large or too complex for just one person (the incident commander) to manage effectively, the IC may assign other individuals to oversee parts of the incident. Everything that occurs at an emergency incident can be divided among the four major functional components within ICS:

- Operations
- Planning
- Logistics
- Finance/Administration

### Operations

The Operations Section, which is typically led by an Operations Section Chief on larger incidents, carries out the objectives developed by the IC and is responsible for all tactical

Figure 5-13 The organizational structure of the Operations Section.

Figure 5-14 Divisions and groups are organized to manage the span of control and to supervise and coordinate units working together.

operations at the incident Figure 5-13. The Operations Section Chief directs and manages the resources assigned to his or her section. These resources could include fire units of any type, law enforcement resources, emergency medical units, airborne resources such as helicopters and fixed-wing aircraft, and hazardous materials response resources. This position is usually assigned when complex incidents involve more than 20 single resources or when the IC cannot be involved in all details of the tactical operation.

### Groups and Divisions

Organizational units such as groups and divisions are established to aggregate single resources or crews under one supervisor. The primary reason for establishing groups and divisions is to maintain an effective span of control.

A Hazardous Materials Group, led by a Hazardous Materials Group Supervisor, is often established when companies and crews are working on the same task or objective, albeit not necessarily in the same location. The term "group" is very specific as it applies to the ICS: A *group* is assembled to relieve span of control issues and is considered to consist of functional assignments that may not be tied to any one geographic location. A division usually refers to companies and crews that are working in the same geographic location. Groups and divisions place several single resources under one supervisor, effectively reducing the IC's span of control Figure 5-14.

### Hazardous Materials Branches

If necessary during a hazardous materials incident, a special technical group may be developed under the Operations Section, known as the Hazardous Materials Branch Figure 5-15. The Hazardous Materials Branch consists of some or all of the following staff positions as needed for the safe control of the incident:

- A hazardous materials safety officer, sometimes referred to as the assistant safety officer (ASO), is responsible for the hazardous materials team's safety only. When a Hazardous Materials Branch or Hazardous Materials Group has been established, or when the incident requires a dedicated hazardous materials response, the safety officer may appoint a hazardous materials safety officer to the Hazardous Materials Branch or the Hazardous Materials Group. This particular hazardous materials safety officer reports directly to the safety officer, who in turn reports directly to the IC.
- The entry team is assigned to enter into the designated hot zone.
- A decontamination team is responsible for reducing and preventing the spread of contaminants from persons and equipment.
- A backup team is a team of fully qualified and equipped responders who are ready to enter the hot zone at a moment's notice to rescue any members of the hot zone entry team.
- A technical reference team gathers information and reports to the IC as well as the hazardous materials safety officer.

A branch represents a higher level of combined resources than either a division or a group. At a major incident, several different activities may occur in separate geographic locations or involve distinct functions. Span of control might still present a problem, even after the establishment of divisions and groups. In these situations, the IC can establish branches to place a higher-level supervisor (a Hazardous Materials Branch Director) in charge of a number of divisions and groups.

The Hazardous Materials Branch Director reports to the Operations Section Chief or directly to the IC if the Operations Section Chief position is not assigned. Responsibilities of the Hazardous Materials Branch Director include obtaining a briefing from the IC, staffing the Hazardous Materials Branch functions as required, ensuring that scene control zones are established, ensuring that a site safety plan is developed, maintaining accountability, ensuring that proper PPE is worn, and ensuring that the operational objectives are being met. Other functional positions that may be filled under a Hazardous Materials

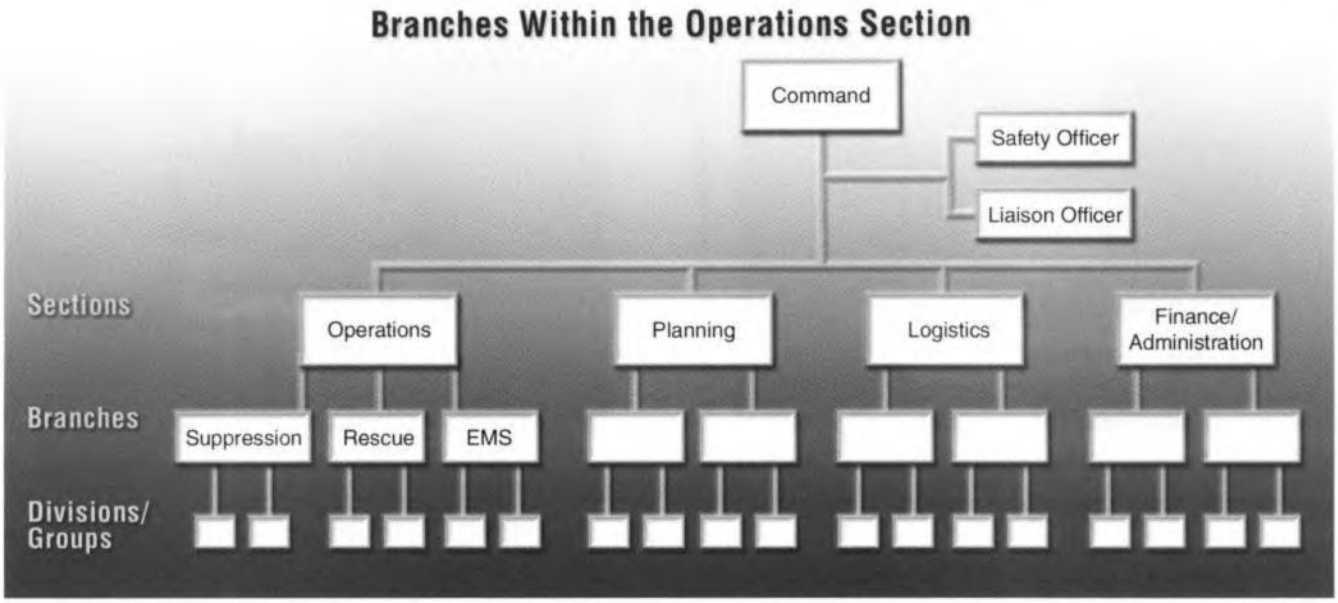



Figure 5-15 Creating branches within the Operations Section is one way to manage the span of control during a large incident.

Branch Director include site access group supervisor, decontamination group supervisor, and entry group supervisor. The management structure and the ICS positions that are ultimately assigned are based on the needs associated with the specific incident.

**Responder Tips**

There is only one safety officer (or incident safety officer) for the entire incident, but that position may have many assistants.

In some types of incidents, such as a wildland fire or a multi-story structure fire, the safety officer may assign an assistant to each division working the fire. (Remember, the command system is intended to be flexible.) Responsibilities of the hazardous materials safety officer include obtaining a briefing from the IC or the safety officer and/or the Hazardous Materials Branch Director, participating in the preparation of the site safety plan, providing or participating in the safety briefing, altering or suspending any activity that poses an imminent threat to the responders, and maintaining accountability for all resources assigned to the hazardous materials mitigation efforts.

### Planning

The Planning Section is responsible for the collection, evaluation, dissemination, and use of information relevant to the incident. The Planning Section, which is led by a Planning Section Chief, acts as the central point for collecting information on the situation status (sit-stat) of the event, tracking and logging on-scene resources, and disseminating the written incident action plan Figure 5-16. On large-scale incidents, the Planning Section Chief facilitates the incident briefings and planning meetings.

Figure 5-16 The organizational structure of the Planning Section.

### Logistics

The Logistics Section can be viewed as the support side of an incident management structure. This section within the ICS is responsible for providing facilities, services, and materials for the incident. Logistics is headed by a Logistics Section Chief, who is responsible for providing the bulk of the support functions for an incident Figure 5-17. This position is generally assigned on long-duration or resource-intensive, complex incidents.

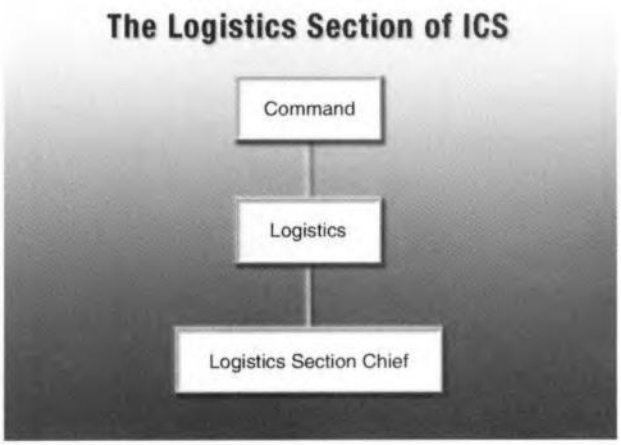



Figure 5-17 The organizational structure of the Logistics Section.

Figure 5-18 The organizational structure of the Finance/Administration Section.

Logistical support includes food, sleeping facilities, transportation needs, sanitation facilities, showers, and all other requests for resources needed to manage the incident. If someone on the incident needs a truckload of sand, for example, the Logistics Section is the group that makes it happen. When resources are needed, the requesting person follows the appropriate chain of command to route the request to Logistics. It is then up to Logistics personnel to determine whether they will be able to fill the request. Typically, during a planning meeting at a large incident, the Operations Section Chief, Planning Section Chief, safety officer, IC, and a small core of other key management positions meet to discuss the logistical needs of the incident based on the operational objectives. The Logistics Section then determines whether those needs can be met, and if so, under what time frame.

### Finance

The Finance/Administration Section tracks the costs related to the incident, handles procurement issues, records the time that responders are on the incident for billing purposes, and keeps a running cost of the incident Figure 5-18 ▸. In today's world, cost is certainly a factor in every response, even when it comes to operational objectives. Large-scale incidents can cost millions of dollars to handle, and it's common to see incident objectives tied to financial constraints. Ideally, an incident should be handled in the most cost-effective way possible, so as to minimize the financial impact to the jurisdiction in which the incident occurs.

## Role of the Operations Level Responder

As discussed in Chapter 1 of this text, according to NFPA 472 (2008 edition), operations level responders are those persons who respond to hazardous materials/WMD incidents for the purpose of implementing or supporting actions to protect nearby persons, the environment, or property from the effects of the release; however, these persons may have additional competencies that are specific to their response mission, expected tasks, and equipment and training as determined by the authority having jurisdiction. Clearly, this language identifies operations responders as integral components of an overall response plan to hazardous materials/WMD incidents.

The scope of the operations level responder definition, which was largely expanded by the 2008 version of NFPA 472, provides a jurisdiction with much more flexibility in its operational procedures than ever before, especially where mission-specific competencies are concerned. An AHJ, may, for example, choose to train and utilize operations level responders strictly as support personnel for a group of hazardous materials tech-

**Table 5-1 Hazardous Materials Incident Levels**

| Level I: Lowest Level of Threat | Level II: Medium Level of Threat | Level III: Highest Level of Threat |
|---|---|---|
| A small amount of a low-toxicity/low-hazard substance is involved.<br>The incident can usually be handled by a single agency or engine company.<br>Appropriate level of protection includes turnout gear and SCBA.<br>Example: A small gasoline spill from a motor vehicle accident. | An organized hazardous materials team is needed.<br>Additional chemical protective clothing will be required.<br>Civilian evacuations may be required.<br>Decontamination may need to be performed.<br>Example: A tanker carrying sulfuric acid has overturned in a tunnel and is leaking onto the freeway. | Highly toxic chemicals are involved.<br>Mitigation efforts may require multiple jurisdictions.<br>Large-scale evacuations may be needed.<br>Federal agencies will be called in.<br>Example: A ship in a highly populated harbor catches fire and begins to release chlorine vapors from its cargo area. |

nicians. Alternatively, the AHJ could provide its personnel with the training to satisfy operations level requirements, including both core competencies and all mission-specific competencies, thereby ensuring that its responders can handle a wide variety of hazardous materials/WMD incidents.

As a responder, you should be familiar with all emergency response plans for hazardous materials/WMD incidents that may occur within your jurisdiction. If none exists, as a responder you should default to the scope of practice established by your training when you are called into service, regardless of the nature of the incident.

It is common for a jurisdiction to predetermine response levels and response configurations to anticipated hazards. To that end, agencies use a wide variety of ways to identify and denote the severity of certain types of incidents. Establishing these thresholds takes the guesswork out of determining the type and amount of resources required to handle a particular problem as well as the levels of training required for the responding personnel. Table 5-1 illustrates how an agency might choose to denote the different levels of response. For obvious reasons, the role of the operations level responder will differ depending on the severity of the incident.

# Wrap-Up

## Chief Concepts

- The acronym SIN—which stands for Safety, Isolate, and Notify—is a good place to start when undertaking a hazardous materials response.
- Awareness level responders should ensure scene safety by setting up a barrier around the scene to keep out bystanders and those who are not properly trained or outfitted to engage in the response.
- The three levels of control zones around a hazardous materials incident are the cold zone, the warm zone, and the hot zone. The hot zone is the most contaminated; the cold zone is a safe area.
- All responders should use the buddy system, at every incident.
- A risk-based method of decision making should be employed before people are told to engage in sheltering-in-place or to evacuate from the scene of a hazardous materials incident.
- A safety briefing informs all responders about the health hazards that are known or anticipated at the hazardous materials/WMD incident.
- It is essential for responders to be aware of the signs and symptoms of excessive-heat exposures such as heat exhaustion, heat stroke, heat stress, and dehydration. Become familiar with the cooling technologies used by your AHJ and your own physical capabilities and requirements.
- Two types of cold-temperature exposures are possible: those caused by the release of a material and those caused by the operating environment.
- The incident command system (ICS) has many benefits, including the use of common terminology, consistent organizational structure and position titles, and common incident facilities.
- The ICS can be expanded to handle an incident of any size and complexity.
- The ICS incorporates five functions: command, operations, planning, logistics, and finance/administration.
- The incident commander (IC) is the person in charge of the incident site; he or she is responsible for all decisions relating to the management of the incident.
- The command staff consists of the safety officer, the liaison officer, and the public information officer.
- Groups and divisions are established to aggregate single resources and/or crews under one supervisor.
- A Hazardous Materials Branch consists of some or all of the following staff as needed: a hazardous materials safety officer (assistant safety officer), an entry team, a decontamination team, a backup entry team, and a technical reference team.
- The operations level responder responds to hazardous materials incidents for the purpose of implementing or supporting actions to protect nearby persons, the environment, or property from the effects of the release.

## Hot Terms

Backup team Individuals who function as a stand-by rescue crew or relief for those entering the hot zone (entry team). Also referred to as backup personnel.

Buddy system A system in which two responders always work as a team for safety purposes.

Cold zone A safe area at a hazardous materials incident for those personnel involved in the operations. The incident commander, the command post, EMS providers, and other support functions necessary to control the incident should be located in the cold zone. Also referred to as the clean zone or the support zone.

Command staff Staff positions that assume responsibility for key activities in the incident command system. Individuals at this level report directly to the incident commander. Command staff members include the safety officer, public information officer, and liaison officer.

Control zones Areas at a hazardous materials incident that are designated as hot, warm, or cold, based on safety issues and the degree of hazard found there.

Decontamination team The team responsible for reducing and preventing the spread of contaminants from persons and equipment used at a hazardous materials incident. Members of this team establish the decontamination corridor and conduct all phases of decontamination.

Division An organizational level within the incident command system that divides an incident in one location into geographic areas of operational responsibility.

Emergency decontamination The process of removing the bulk of contaminants off a victim without regard for containment. It is used in potentially life-threatening situations, without the formal establishment of a decontamination corridor.

Entry team A team of fully qualified and equipped responders who are assigned to enter into the designated hot zone.

Finance/Administration Section The command-level section of the incident command system responsible for all costs and financial aspects of the incident, as well as any legal issues that arise.

Hazardous Materials Branch A unit consisting of some or all of the following positions as needed for the safe control of a hazardous materials incident: a second safety officer known as the hazardous materials safety officer (or assistant safety officer), who reports directly to the incident safety officer; a Hazardous Materials Group Supervisor; the entry team; the decontamination team; and the technical reference team.

Hazardous Materials Group A group often established when companies and crews are working on the same task or objective, albeit not necessarily in the same location. A group is specific as it applies to the incident command system and is assembled to relieve span of control issues.

Hazardous materials safety officer A second safety officer dedicated to the safety needs of the Hazardous Materials Branch. Also referred to as the assistant safety officer.

Heat exhaustion A mild form of shock that occurs when the circulatory system begins to fail as a result of the body's inadequate effort to give off excessive heat.

Heat stroke A severe, sometimes fatal condition resulting from the failure of the body's temperature-regulating capacity. Reduction or cessation of sweating is an early symptom; body temperature of 105°F or higher, rapid pulse, hot and dry skin, headache, confusion, unconsciousness, and convulsions may occur as well.

Hot zone The area immediately surrounding a hazardous materials spill/incident site that is directly dangerous to life and health. All personnel working in the hot zone must wear complete, appropriate protective clothing and equipment.

Incident commander (IC) A level of training intended for those assuming command of a hazardous materials incident beyond the operations level. Individuals trained as incident commanders should have at least operations level training and additional training specific to commanding a hazardous materials incident.

Incident command post (ICP) The location in the cold zone where the incident command is located; it is where the command, coordination, control, and communications functions are centralized.

Incident command system (ICS) The combination of facilities, equipment, personnel, procedures, and communications under a standard organizational structure organized so as to manage assigned resources and effectively accomplish stated objectives for an incident.

Incident safety officer The position within the incident command system responsible for identifying and evaluating hazardous or unsafe conditions at the scene of an incident. Safety officers have the authority to stop any activity that is deemed unsafe. Also referred to as the safety officer.

Liaison officer The position within the incident command system that establishes a point of contact with outside agency representatives.

Logistics Section The section within the incident command system responsible for providing facilities, services, and materials for the incident.

Logistics Section Chief The general staff position responsible for directing the logistics function. It is generally assigned on complex, resource-intensive, or long-duration incidents.

Operations Section The section within the incident command system responsible for all tactical operations at the incident. Its personnel carry out the objectives developed by the incident commander.

Operations Section Chief The general staff position responsible for managing all operations activities. It is usually assigned when complex incidents involve more than 20 single resources or when command staff cannot be involved in all details of the tactical operation.

Planning Section The section within the incident command system responsible for the collection, evaluation, and dissemination of tactical information related to the incident and for preparation and documentation of incident management plans.

Planning Section Chief The general staff position responsible for planning functions and for tracking and logging resources. It is assigned when command staff members need assistance in managing information.

Public information officer The position within the incident command system responsible for providing information about the incident. Functions as a point of contact for the media.

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# Wrap-Up

Sheltering-in-place A method of safeguarding people in a hazardous area by keeping them in a safe atmosphere, usually inside structures.

Size-up The rapid mental process of evaluating the critical visual indicators of the incident, processing that information based on training and experience, and arriving at a conclusion that will serve as the basis to form and implement a plan of action.

Technical reference team A team of responders who serve as an information-gathering unit and referral point for both the incident commander and the hazardous materials safety officer (assistant safety officer).

Unified command An incident command system option that allows representatives from multiple jurisdictions and agencies to share command authority and responsibility, thereby working together as a "joint" incident command team.

Warm zone The area located between the hot zone and the cold zone at the incident. Personal protective equipment is required for all personnel in this area. The decontamination corridor is located in the warm zone.

# Responder *in Action*

It is 4:00 A.M. when your engine is dispatched to a report of a 2000-gallon polychlorinated biphenyl (PCB) tank that is slowly leaking at an old manufacturing plant. PCB is a toxic chemical that was banned in the United States in the late 1970s, but can still be found in many older electrical devices. This chemical is very harmful to the environment; it can also cause skin irritation, liver damage, nausea, dizziness, and eye irritation.

At the current incident, approximately 50 gallons of PCB has spilled onto the asphalt and is entering a storm drain. You and your crew must establish control zones to limit exposure to this dangerous chemical.

1. Which of the following most accurately describes the warm zone?
   - **A.** The area immediately around and adjacent to the incident.
   - **B.** The area located between the hot zone and the cold zone. The decontamination corridor is located in the warm zone.
   - **C.** An area where personnel do not need to wear any special protective clothing for safe operation.
   - **D.** The area where the incident command post is located.
2. After doing some research on PCB, you find that this substance is a thick, oily liquid with a low vapor pressure at ambient atmospheric temperature. At the current scene, the leak is occurring approximately 200 yards away from an occupied apartment complex. Which of the following actions would be appropriate for this incident?
   - **A.** Evacuate the apartment complex.
   - **B.** Take no action, as this spill poses no threat of airborne contamination to the apartment complex.
   - **C.** Notify local law enforcement to shelter-in-place all occupants of the apartment complex.
   - **D.** Instruct the public information officer to make an announcement of the spill during the evening news broadcast.
3. After working in PPE for 30 minutes and going through decontamination, one of the responders complains of dizziness and nausea. He is sweating and tells you he feels weak. Which of the following medical conditions most accurately describes his condition?
   - **A.** Heat stroke
   - **B.** Hypothermia
   - **C.** Hypocalcemia
   - **D.** Heat exhaustion
4. The IC decides that the entry team will wear a level of protection that consists of a chemical-resistant suit, boots, gloves, and SCBA. Which of the following classifications best describes this level of protection?
   - **A.** Level A
   - **B.** Level B
   - **C.** Level C
   - **D.** Level D

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CHAPTER

# 6

## NFPA 472 Standard

### Competencies for Awareness Level Personnel

NFPA 472 contains no competencies for awareness level personnel.

### Core Competencies for Operations Level Responders

NFPA 472 contains no competencies for operations level responders.

## Knowledge Objectives

After studying this chapter, you will be able to:

- Describe the threat posed by terrorism.
- Understand the definition of terrorism from a broad perspective.
- Describe various types of potential terrorist targets.
- Understand the dangers posed by explosive devices and secondary explosive devices.
- Define weapons of mass destruction.
- Understand the basic differences and indicators of chemical, biological, and radiological threats.
- Describe operations considerations at a terrorism event, including initial actions, interagency coordination, decontamination, mass casualties, and triage.
- Identify the different levels distinguished in the Homeland Security Threat Level chart.

## Skills Objectives

There are no skills objectives for this chapter.

## You Are the Responder

Your engine company has been dispatched to a local government office building for a reported explosion. When you arrive on the scene, you do not observe any indications of fire or damage, but people are running from the building. Many of them complain of eye irritation and difficulty breathing. One person tells you that she heard a loud popping sound from a nearby office and that some employees were showered with an unknown liquid substance. You quickly learn that there are still people in the office. Some are unconscious; others appear to be having seizures.

1. Is the information provided at this incident typical for most fires or explosions?
2. Which characteristics of this situation would cause you concern?
3. What is your primary concern as you enter the office building?

## Introduction

Reflecting the rising threat posed by terrorism, the 2008 edition of NFPA 472, *Standard for Competence of Responders to Hazardous Materials/Weapons of Mass Destruction Incidents,* outlines the following operational philosophy:

> Emergency response operations to a terrorism or criminal scenario using hazardous materials are based on the basic operational concepts of hazardous materials response. In simple terms, responders cannot safely and effectively respond to a terrorism or criminal scenario involving hazardous materials/weapons of mass destruction (WMD) if they do not first understand hazardous materials response.

There are no NFPA 472 competencies listed for this chapter because the competencies listed in the other chapters of this text also apply to weapons used for mass destruction and terrorist incidents (in addition to hazardous materials incidents). This chapter provides an overview of terrorism and profiles some of the agents that emergency personnel may encounter at these incidents. Readers seeking information on agent-specific tasks—such as those associated with incidents involving biological, chemical, and radiological agents, for example—should consult the Annex sections of NFPA 472. The Annex information is nonmandatory and is not considered to be part of the requirements of NFPA 472. It is designed to provide additional information over and above the core competencies and certain mission-specific competencies.

Terrorism, as defined in the U.S. Code of Federal Regulations, can be described as "the unlawful use of force and violence against persons or property to intimidate or coerce a government, the civilian population, or any segment thereof, in furtherance of political or social objectives." This broad definition encompasses a wide range of acts committed by different groups for different purposes.

Simply put, the goal of terrorism is to produce feelings of fear in a population or group. Terrorism is not limited to incidents involving certain tools or weapons, however. In fact, almost anything can potentially be used as a tool by terrorists. For example, a gasoline tanker could be intentionally wrecked and burned in an attempt to destroy property or injure people. Such an event could be viewed as having criminal intent or it could be viewed as an act of terrorism. Yet, if an identical gasoline tanker crashed and caught fire due to driver error, we would call the incident an accident. At the time the event occurs, the distinction between an event with criminal intent and an accident may not be so clear. It is in those first moments that responders must rely on their training and standard operating procedures to safely and efficiently handle the problem—whether it was intentionally caused or not.

The Federal Bureau of Investigation (FBI) classifies terrorism as either domestic or international in nature. *Domestic terrorism* refers to acts that are committed within the United States by individuals or groups that operate entirely within the United States and are not influenced by any foreign interests. *International terrorism* includes any acts that transcend international boundaries.

On September 11, 2001, the largest terrorist events in the history of the United States occurred—the attacks on the World Trade Center, the Pentagon, and United Airlines Flight 93, the airplane that crashed in Shanksville, Pennsylvania. Collectively, these events resulted in almost 3000 deaths Figure 6-1 ▸.

Although acts of terrorism can occur at any time, these types of incidents have not become commonplace in the United States. During 2007, the U.S. Department of State reported no deaths in the country from terrorist events. Despite these data,

Figure 6-1 The September 11 attacks on the World Trade Center and the Pentagon accounted for the majority of the deaths caused by terrorists in 2001.

responders should not rule out the threat of terrorism as a possibility on U.S. soil. The entire emergency response community must remain vigilant and ready to respond to any type of hazardous materials/WMD event.

## Responding to Terrorist Incidents

The roles of all public safety responders in handling terrorist events involve many of the same functions that these responders perform on a day-to-day basis. Regardless of the intent behind the incident, responders are required to make risk-based decisions on tactics and strategy, personal protective equipment (PPE), victim rescue and/or evacuation, decontamination, and information obtained during detection and monitoring activities—the entire gamut of actions required to solve the problem.

What is different during a terrorist incident is the landscape upon which that incident is handled, and the interagency cooperation that must occur. An incident with criminal intent, causing widespread destruction and/or numerous casualties, will require the involvement of many local, state, and federal law enforcement agencies; emergency management agencies; allied health agencies; and the military. It is critical that all of these agencies train together and work together in a coordinated and cooperative manner. Most likely, a unified command will be established, with many agencies working on different aspects of the incident. An incident involving a WMD could quickly overwhelm your agency, neighboring agencies, and the local healthcare system. To that end, it is important to understand which assets and capabilities of those regional agencies may be available to assist with a large-scale incident.

### Potential Targets and Tactics

Terrorists are motivated by a cause and choose targets they believe will help them achieve their goals and objectives. Terrorist incidents aim to instill fear and panic among the general population and to disrupt daily ways of life. Given this goal, terrorists tend to choose symbolic targets, such as places of worship, embassies, monuments, or prominent government buildings. Sometimes the objective is sabotage—that is, to destroy or disable a facility that is significant to the terrorist cause. The ultimate goal could be to cause economic turmoil by interfering with transportation, trade, or commerce.

Terrorists choose a method of attack they think will make the desired statement or achieve the maximum results. They may vary their methods or change their approach over time. Explosive devices have remained popular weapons for terrorists, however, and have been used in thousands of terrorist attacks. In recent years, the number of suicide bombings has increased significantly, emphasizing the high threat level posed by terrorist-constructed explosives.

In the 1980s, many terrorist incidents involved the taking of hostages on hijacked aircraft or cruise ships. Sometimes, only a few people were held; at other times, hundreds of people were taken hostage. Diplomats, journalists, and athletes were targeted in several incidents, and the terrorists often offered to release their hostages in exchange for the release of imprisoned individuals allied with the terrorist cause. More recently, terrorist actions have endangered thousands of lives without giving authorities an opportunity to bargain for the victims' safety. According to the U.S. Department of State, during 2007, 17 U.S. citizens worldwide were kidnapped as a result of incidents of terrorism.

Terrorism can occur in any community and in connection with many different issues. Many causes inspire passion in their supporters, who may range from members of peaceful, nonviolent organizations to advocates of fanatical fringe groups. For example, a rural ski lodge tucked away in the mountains may be attacked by an environmental group that is upset with its plans for expansion. A small retailer in an upscale suburban community could become the target of an animal rights group that objects to the sale of fur coats. An antiabortion group might plant a bomb at a local community health clinic.

It is often possible to anticipate likely targets and potential attacks. Law enforcement agencies routinely gather intelligence about terrorist groups, threats, and potential targets. The fire service, in conjunction with law enforcement agencies, is increasingly engaging in intelligence sharing so that preincident plans can be developed for possible targets and scenarios. Even if no specific threats have been made, certain types of occupancies are known to be potential targets; preincident planning for those locations should take into account the possibility of a terrorist attack and an accidental fire.

Figure 6-2 Subways, airports, bridges, and hospitals are all vulnerable to attack by terrorists who seek to interrupt a country's infrastructure.

News reports about terrorist incidents abroad can help keep responders current with trends in terrorist tactics. These accounts can provide useful information about situations that could occur in your jurisdiction in the future. A variety of Internet resources can also help responders to keep abreast of current threats. Periodic e-mails issued by list servers, which are available through federal response agencies, can provide a variety of useful information. By becoming familiar with potential targets and current tactics, emergency responders can plan appropriate strategies and anticipate use of certain tactics for potential attacks.

## Classification of Terrorist Targets

Potential targets for terrorists include natural landmarks and human-made structures. These sites can be classified into three broad categories: infrastructure targets, symbolic targets, and civilian targets.

### Infrastructure Targets

Terrorists might select bridges, tunnels, subways, or hospitals as targets in an attempt to disrupt transportation and inflict a large number of casualties Figure 6-2▲. They might also plan to attack the public water supply or try to disable the electrical power distribution system, telephones, or the Internet. Disruption of a community's 9-1-1 system or public safety radio network would have a direct impact on emergency response agencies.

### Symbolic Targets

National monuments such as the Lincoln Memorial, Washington Monument, or Mount Rushmore could be targets for groups who want to attack symbols of national pride Figure 6-3▼. Foreign embassies and institutions might be attacked by groups promoting revolution within those countries or protesting their international policies. Religious institutions are potential targets of hate groups. By targeting these symbols, terrorist groups

Figure 6-3 Terrorists might attempt to destroy visible national icons.

Figure 6-4 By attacking civilian targets such as a crowded stadium, terrorists might make citizens feel vulnerable in their everyday lives.

seek to make people aware of their demands and to create a sense of fear in the public.

### Civilian Targets

Civilian targets include places where large numbers of people gather, such as shopping malls, schools, or sports stadiums. In incidents involving these sites, the goal of terrorists is to indiscriminately kill or injure large numbers of people, thereby creating fear in the larger society Figure 6-4 ▲.

Terrorism can also be classified according to the part of society that is targeted—for example, agroterrorism, ecoterrorism, and cyberterrorism. Incidents of terrorism involving these three tactics will probably not have as much of a direct impact on fire and police departments as incidents involving natural landmarks and human-made structures, however. Incidents involving cyberterrorism, for instance, will directly affect the fire department and could significantly disrupt its operations, but would probably not require a fire department response.

Figure 6-5 Agroterrorism affects food supply or the agricultural industry.

## Responder Tips

**Potential Terrorist Targets**

**Infrastructure Targets**
Bridges and tunnels
Emergency facilities
Hospitals
Oil refineries
Pipelines
Power plants
Railroads
Telecommunications systems
Water reservoirs and treatment plants

**Symbolic Targets**
Embassies
Government buildings
Military bases
National monuments
Places of worship

**Civilian Targets**
Arenas and stadiums
Airports and railroad stations
Mass-transit systems
Schools and universities
Shopping malls
Theme parks

**Ecoterrorism Targets**
Controversial development projects
Environmentally sensitive areas
Research facilities

**Agroterrorism Targets**
Crops
Feed storage
Grain elevators
Livestock and poultry

**Cyberterrorism Targets**
Banking and finance computer systems
Business computer systems
Court computer systems
Government computer systems
Law enforcement computer systems
Military computer systems

### Ecoterrorism

Ecoterrorism refers to illegal acts committed by groups supporting environmental or related causes. Examples include spiking trees to sabotage logging operations, vandalizing a university research laboratory that is conducting experiments on animals, and firebombing a store that sells fur coats. Research and development projects and facilities are also often targets of ecoterrorists.

### Agroterrorism

Agroterrorism includes the use of chemical or biological agents to attack the agricultural industry or the food supply Figure 6-5 ◄. The deliberate introduction of an animal-targeted disease, such as foot-and-mouth disease within the livestock

population, could result in major losses to the food industry and produce fear among members of the general population. Internationally, fire fighters have been called to assist in the destruction of livestock, decontamination, and other response capacities in agriculture-related incidents.

### Cyberterrorism

Groups or terrorists could engage in cyberterrorism by electronically attacking government or private computer systems. In the past, many attempts have been made to disrupt the Internet or to attack government computer systems and other critical networks. This type of terrorism seeks to disrupt many day-to-day activities in society, as the use of computers is woven into most things we do as part of contemporary life.

Figure 6-6 Every year, thousands of pounds of explosives are stolen from their rightful owners.

## Devices

Terrorists can turn the most ordinary objects into powerful weapons. For example, we tend to think of gasoline tankers and commercial airliners as valuable parts of our society, but in the hands of determined terrorists these devices could become deadly weapons. As mentioned earlier, designating an incident as an act of terrorism reflects more the intent of the attacker than the use of a certain device. For example, demolition companies use explosives to bring down unneeded structures quickly and safely; terrorists could use the same explosives to bring down an occupied building, deliberately killing many people. Again, it is the intent that distinguishes between an accident and a terrorist event.

Although bombings are the most frequent terrorist acts, responders also must be aware of the threats posed by other potential weapons. Shooting into a crowd at a shopping mall or a train station with an automatic weapon could cause devastating carnage. The release of a biological agent into a subway system could make numerous people become ill and die, simultaneously creating a public panic response that could overload the local fire department, EMS, law enforcement, and hospitals. A computer virus that attacks the banking industry could cause tremendous economic losses. Given the breadth of these threats, planning should consider the full range of possibilities.

### Explosives and Incendiary Devices

In 2006, the U.S. Bureau of Alcohol, Tobacco, Firearms and Explosives (ATF) reported 3445 explosive incidents, resulting in 135 injuries and 14 fatalities. Groups or individuals have used explosives for many different purposes: to further a cause, to intimidate a co-worker or former spouse, to take revenge, or simply to experiment with a recipe found in a book or on the Internet.

Each year, thousands of pounds of explosives are stolen from construction sites, mines, and military facilities Figure 6-6. How much of this material makes its way to criminals and terrorists is not known.

Terrorists can also use commonly available materials, such as ammonium nitrate fertilizer and fuel oil (ANFO), to create their own blasting agents. An improvised explosive device (IED) is any explosive device that is fabricated from readily available materials. An IED could be contained in almost any type of package from a letter bomb to a truckload of explosives. The Unabomber, for example, constructed at least 16 bombs that were delivered in small packages through the U.S. Postal Service. By contrast, the bombings of the World Trade Center in 1993 and the Alfred E. Murrah Federal Building in 1995 both involved delivery vehicles loaded with ANFO and detonated by a simple timer Figure 6-7.

#### Pipe Bombs

The most common IED is the pipe bomb. A pipe bomb is simply a length of pipe filled with an explosive substance and rigged with some type of detonator Figure 6-8. Most pipe bombs are simple devices that contain black powder or smokeless powder and are ignited by a hobby fuse. More-sophisticated pipe bombs may contain a variety of chemicals and incorporate electronic timers, mercury switches, vibration switches, photocells, or remote control detonators as triggers.

Figure 6-7 The Alfred E. Murrah Federal Building in Oklahoma City was destroyed by a truck bomb in 1995.

Figure 6-8 Pipe bombs come in many shapes and sizes.

Pipe bombs are sometimes packed with nails or other objects that act as shrapnel; their expulsion is intended to inflict as much injury as possible on anyone in the vicinity. A chemical or biological agent or radiological material could be added to a pipe bomb to create a much more complicated and dangerous incident. Experts can only speculate at the number of casualties that could result from the use of such a weapon.

### Secondary Devices

Emergency responders must realize that terrorists may have placed a secondary device in the area where an initial event has occurred. These devices are intended to explode some time after the initial device detonates. As discussed in Chapter 4, secondary devices are designed to kill or injure emergency responders, law enforcement personnel, spectators, or news reporters. Terrorists have used this tactic to attack the best-trained and most experienced investigators and emergency responders, or simply to increase the levels of fear and chaos following an attack. Remember the NFPA mnemonic (EVADE) when considering the presence of a secondary device.

**E**valuate the scene for likely areas where secondary devices may be placed.

**V**isually scan operating areas for a secondary device before providing patient care.

**A**void touching or moving anything that may conceal an explosive device.

**D**esignate and enforce scene control zones.

**E**vacuate victims, other responders, and non-essential personnel, as quickly and safely as possible.

The use of secondary devices is a common tactic in incidents abroad and has occurred at a few incidents in North America. For example, in 1998, a bomb exploded outside a Georgia abortion clinic. Approximately an hour later, a second explosion at the same site injured seven people, including two emergency responders. A similar secondary device was discovered approximately one month later at the scene of a bombing in a nearby community, although responders were able to disable this device before it detonated.

### Potentially Explosive Devices

Responders, fire department, and law enforcement units responding to an incident that involves a potentially explosive device—one that has not yet exploded—should remove all civilians from the area and establish a perimeter at a safe distance. At no time should any emergency responder handle a potential explosive device unless he or she has received special training to do so. Trained explosive ordnance disposal (EOD) personnel should assess the device and render it inoperative.

While waiting for the properly trained EOD personnel to arrive, responders should establish a command post and a staging area Figure 6-9. Because secondary devices may be present, the staging area should be located at a safe distance from the incident site. Follow your standard operating procedures to determine where the command post should be established. Nevertheless, responders must make informed decisions as to appropriate locations for staging areas and evacuation actions. In this type of incident, a joint command structure (commonly referred to as a unified command) is usually established to coordinate the activities of all agencies participating in the response.

If the bomb disposal team decides to disarm the device, an emergency action plan must be developed in case an accidental detonation occurs. The incident commander (IC) should work in concert with law enforcement and EOD personnel to determine a safe perimeter where responders will be staged.

In some cases, a forward staging area may be established. A rapid intervention team then stands by to provide immediate assistance to the bomb disposal team if something goes wrong. Other fire fighters and emergency medical personnel would remain in a remote staging area in this scenario.

### Actions Following an Explosion

As a first responder, your first priority should be to ensure your own safety, followed by ensuring the safety of the scene. During the initial stages of an incident, you will not know whether the event was caused by an intentional act or resulted from accidental circumstances. In any incident following an explosion,

Figure 6-9 The first responders to arrive at the scene of an explosion should establish a command post in a safe location and begin the process of setting up a unified command with law enforcement.

# Voices *of* Experience

Everyone remembers where and what they were doing on September 11, 2001. As I was watching TV, the second plane hit. I knew then that this was not an accident, but a terrorist attack.

One week later to the day, I was on final approach to New York. A large hole could be seen in lower Manhattan where the twin towers of the World Trade Center had once stood. I went to New York because I needed to be there. I had a lot of friends in the New York Fire Department (FDNY), most of whom had perished on September 11.

*"Her 11-year-old son had learned how to make bombs on the Internet."*

For the next eight years I would travel to Maspeth, New York, and spend one week each year with Hazmat-1. I would bring back the training I learned to my department and share it.

At Ground Zero, words cannot begin to explain what I saw. What I learned is that terrorism is real, and we need to think outside of the box and realize that terrorism can happen anywhere. The use of the Internet provides us with anything and everything—and some Web sites provide step-by-step illustrated diagrams on how to make a weapon or bomb. There is no such thing as a routine call when you consider these factors. I once had a mother call me at the station and ask if I could come over and check out something she had found in her son's room. She stated it was a couple of pipes, and it made a noise when she shook it. Based on this information, I asked her to exit the house and called the bomb team: Her 11-year-old son had learned how to make bombs on the Internet.

Agencies in small cities and towns need to accept that terrorism could happen to them. They need to keep up on their skills and use extra caution. Routine calls are not routine anymore.

Tom Zeigler
Missoula Rural Fire District
Missoula, Montana

follow departmental procedures to ensure the safety of rescuers, victims, and bystanders. Consider the possibility that a secondary device may be in the vicinity. Quickly survey the area for any suspicious bags, packages, or other items.

It is also possible that chemical, biological, or radiological agents may be involved in a terrorist bombing. For this reason, qualified personnel with monitoring instruments should be assigned to check the area for potential contaminants. The initial size-up should also include an assessment of hazards and dangerous situations. Likewise, the stability of any building involved in the explosion must be evaluated before anyone is permitted to enter. Entering an unstable area without proper training and equipment may complicate rescue and recovery efforts.

#### Working with Other Agencies

Joint training with local, state, and federal agencies charged with handling incidents involving explosive devices should occur on a routine basis. Among these agencies are local and state police; the FBI; the Bureau of Alcohol, Tobacco, Firearms and Explosives; and military EOD units. In some jurisdictions, the fire department is responsible for handling explosive devices. In other communities, this function is performed by specially trained law enforcement personnel.

## Agents

The greatest threat posed by terrorists is the use of weapons of mass destruction (WMD). These weapons include chemical, biological, and radiological agents, as well as conventional weapons and explosives. *The annex information found in NFPA 472 provides additional, specific information about the various agents that may be used in a terrorist attack.* Keep in mind this important fact: An incident involving a WMD is intended to cause widespread panic, death, and injury. In some cases, responders run the risk of becoming victims as well. Take extra care and be observant when responding to incidents where large numbers of victims are found, or where an explosion or shooting has occurred at a mass-gathering event such as a sporting event. The following sections are intended to provide you with an overview of some of the agents that might be used with criminal intent.

### Chemical Agents

Chemical agents have the potential to kill or injure large numbers of people. Many chemical agents are readily available in this country because they are produced in the United States and used in a broad range of industrial and commercial processes. For instance, chlorine is used for many purposes, including purification of drinking water and swimming pools. These chemicals are stored and transported in various-sized containers, ranging from small pressurized cylinders to railroad tank cars. These same chemicals, if released in a terrorist event, could cause injury or death to many people. Mitigating an accidental release of chlorine gas, however, requires the same safety precautions as an intentional release of chlorine gas by terrorists.

Chemical agents are not new; in fact, they have been used as weapons for at least 100 years. Phosgene, chlorine, and mustard agents were used in World War I, resulting in thousands of battlefield deaths and permanent injuries. Chemical weapons were also used during the Iran–Iraq War (1980 to 1988). During the same period, the Iraqi government used these types of weapons against the minority Kurdish people in its own country. Although international agreements prohibit the use of chemical and biological agents on the battlefield, great concern remains that terrorists could use chemical weapons.

In 1995, the religious cult Aum Shinrikyo released a chemical nerve agent, sarin, into the Tokyo subway system. Although the attack resulted in 12 deaths and several thousand injuries, many experts suggest that this attack was ineffective because relatively few casualties occurred even though thousands of subway riders were potentially exposed to the chemical agent. Even so, this attack achieved one of the major goals of terrorism: It instilled fear in a large population.

The basic instructions for making chemical weapons can be found quickly by accessing the Internet, books, and other publications. Many of the chemicals are routinely used in legitimate industrial processes and are readily available. For example, as mentioned earlier, chlorine gas is used in swimming pools, at water treatment facilities, and in industry Figure 6-10. Despite its legitimate uses, chlorine is classified as a pulmonary agent (a choking agent) because its inhalation causes severe pulmonary damage.

Figure 6-10 Although chlorine is regularly used in swimming pools and water treatment facilities, it is classified as a pulmonary agent that can be used in a terrorist attack.

Like chlorine, cyanide has many legitimate uses, but it kills quickly once it enters the body. Cyanide compounds such as hydrogen cyanide (HCN) are used in the production of paper and synthetic textiles as well as in photography and printing.

When cyanide enters the body, either by inhalation, ingestion, absorption, or injection, it acts as a cellular asphyxiant. Cyanide deactivates cytochrome oxidase, an enzyme that facilitates the transfer of oxygen from the blood into the cells. When this occurs, the body's metabolism shifts from aerobic to anaerobic, which causes the build-up of lactic acid and other toxic by-products of the metabolic process.

Unfortunately, administering oxygen to a patient exposed to cyanide does little good—the body simply cannot use the oxygen in the cells. Death will result unless the cyanide is removed from the body. This removal is accomplished by administering a chemical antidote such as the Cyanide Antidote Kit (CAK) or Cyanokit® Figure 6-11. These chemical antidotes draw the cyanide compound off the cytochrome oxidase, thereby allowing oxygen to enter the cells and restoring the normal process of aerobic metabolism. Administering these antidotes is considered to be an advanced life support skill, such that these measures must be administered by a paramedic, physician, or nurse.

Figure 6-12 Crop-dusting equipment could be used to distribute chemical agents.

**Responder Safety Tips**

Preincident planning at infrastructure, symbolic, and civilian targets should take into account the possibility of a terrorist attack.

**Responder Safety Tips**

Depending on the dose, exposure to cyanide compounds (potassium cyanide, sodium cyanide, hydrogen cyanide) may produce acute signs and symptoms including nausea, vomiting, confusion, and rapid breathing. Exposures to high levels of cyanide can quickly cause an altered level of consciousness, coma, and death. Medical treatments are available, but they need to be used immediately for severely exposed victims.

Figure 6-11 A cyanide antidote kit.

Chemical weapons can be disseminated in several ways. For example, simply releasing chlorine gas from a storage tank in an unguarded rail yard could cause thousands of injuries and deaths. To ensure broader distribution of the chemical agent, however, a chemical agent might be added to an explosive device. Crop-dusting aircraft, truck-mounted spraying units, and hand-operated pump tanks could all potentially be used to disperse an agent over a wide area Figure 6-12.

The extent of dissemination of a toxic gas or suspended particles depends on wind direction, wind speed, air temperature, and humidity at the time of the material's release. Because these factors can change quickly, it is difficult to predict the exact direction that might be taken by a chemical release cloud. Hazardous materials teams use computer models to predict the pathway of a toxic cloud. They also have the training and equipment to safely handle these situations.

### Nerve Agents

Nerve agents are toxic, chemical agents that attack the central nervous system. These weapons were first developed in Germany before World War II. Nerve agents are similar to some pesticides (organophosphates) but are much more toxic—in some cases, 100 to 1000 times more toxic than similar pesticides. Exposure to these substances can result in injury or death within minutes.

**Responder Tips**

When pure, nerve agents are colorless and, in most cases, take the form of mobile liquids. In an impure state, nerve agents may appear as yellowish to brown liquids. Some nerve agents have a faint fruity odor.

Figure 6-13 In their normal states, nerve agents are liquids. They must be dispersed in aerosol form if they are to be inhaled or absorbed by the skin.

In their normal states, most nerve agents are liquids Figure 6-13. As liquids, nerve agents are not likely to contaminate large numbers of people because direct contact with the agent is required. To be an effective weapon, the liquid must either be dispersed in aerosol form or be broken down into fine droplets so that it can be inhaled or absorbed through the skin.

Pouring a liquid nerve agent onto the floor of a crowded building would probably not immediately contaminate large numbers of people; however, this act would produce fear and panic. In such a scenario, the effectiveness of the agent would depend on how long it remained in the liquid state and how widely it became dispersed throughout the building. Sarin, the most volatile nerve agent, evaporates at the same rate as water and is not considered persistent. The most stable nerve agent, V-agent (VX), is considered persistent because it takes several days or weeks to evaporate. Common nerve agents, their method of contamination, and specific characteristics are listed in Table 6-1.

When a person is exposed to a nerve agent, symptoms of that exposure will become evident within minutes. The symptoms may include pinpoint pupils, runny nose, drooling, difficulty breathing, tearing, twitching, diarrhea, convulsions or seizures, and loss of consciousness Figure 6-14. The same symptoms are seen in individuals who have been exposed to pesticides.

Several mnemonics can help you remember the symptoms of a nerve agent exposure. The mnemonic used most often in the emergency response community is SLUDGE Table 6-2.

Keep in mind that such mnemonics represent a very basic and limited way to identify a nerve agent exposure. From a medical standpoint, an exposure of this type involves both the sympathetic and parasympathetic nervous systems—each having its own unique set of signs and symptoms. It is beyond the scope of this text to detail the signs and symptoms of a nerve agent exposure. Advanced life support providers (paramedics, for example) have more training and in-depth knowledge when

**Table 6-1 Common Nerve Agents**

| Nerve Agent | Method of Contamination | Characteristics |
|---|---|---|
| Tabun (GA) | Skin contact<br>Inhalation | Disables the chemical connections between nerves and target organs |
| Soman (GD) | Skin contact<br>Inhalation | Odor of camphor |
| Sarin (GB) | Skin contact<br>Inhalation | Evaporates quickly |
| V-agent (VX) | Skin contact | Oily liquid that can persist for weeks |

A.

B.

Figure 6-14 Pupil responses. **A.** Normal. **B.** Pinpoint.

**Table 6-2 Symptoms of Nerve Agent Exposure**

**S**–salivation (drooling)
**L**–lacrimation (tearing)
**U**–urination
**D**–defecation
**G**–gastric upset (upset stomach, vomiting)
**E**–emesis (vomiting)

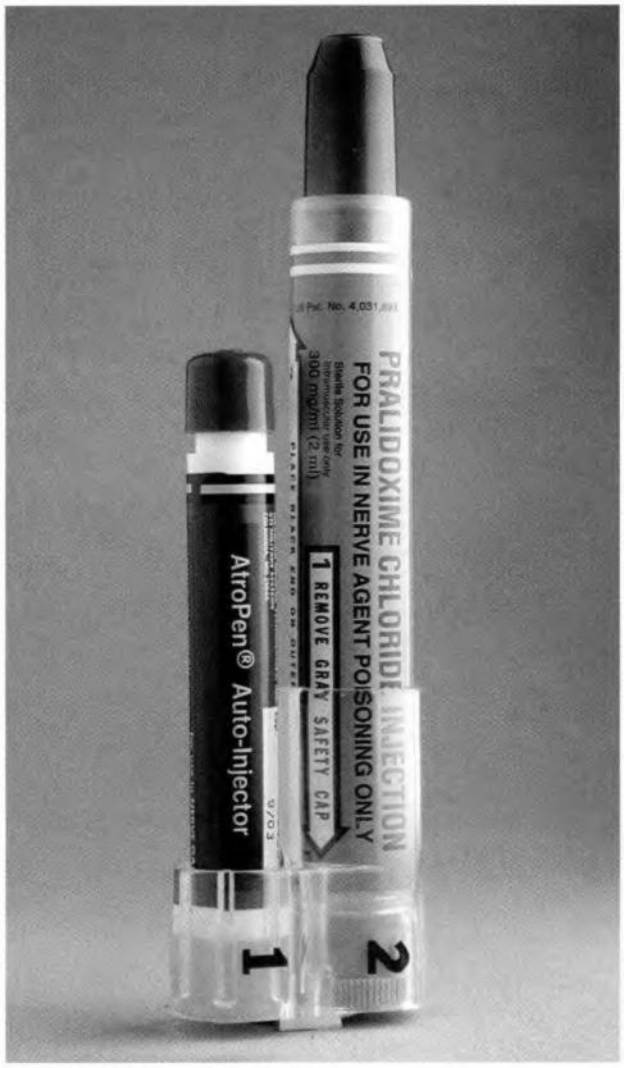


Figure 6-15 Items from a Mark 1 Nerve Agent Antidote Kit.

it comes to recognizing the signs and symptoms of a nerve agent exposure. Additionally, many Internet and print resources are available for further study on the subject.

In terms of medical treatment for a nerve agent exposure, the most common treatment is the Mark 1 Nerve Agent Antidote Kit (NAAK) Figure 6-15. This nerve agent antidote kit contains two medications—2 mg of atropine and 600 mg of pralidoxime chloride (2-PAM)—in two separate auto-injectors. An updated version of the Mark 1 is the DuoDote™. The DuoDote™ contains 2.1 mg of atropine and 600 mg of 2-PAM and is delivered as a single dose through one needle. These kits have been provided to many fire departments' hazardous materials teams. In addition, many law enforcement agencies and EMS units around the United States carry these antidotes on their response vehicles.

The antidote medications can be quickly injected into a person who has been contaminated by a nerve agent. Peak atropine levels are reached approximately 5 minutes after administration; peak levels of 2-PAM are achieved in 15 to 20 minutes. For the emergency responder, this delay means that you should not expect to administer this antidote to a person exhibiting serious signs and symptoms of a nerve agent exposure and have the patient recover right away, or even at all. Auto-injectors are not an immediate cure-all. In fact, they may be ineffective if the victim has suffered a significant exposure to a nerve agent or pesticide.

**Responder Tips**

Auto-injectors are intended for patients between the ages of 18 and 55 years of age.

Each drug in the auto-injector has a specific target and acts independently to reverse the effects of a nerve agent exposure. Atropine, for example, may reverse muscarinic effects such as runny nose, salivation, sweating, bronchoconstriction, bronchial secretions, nausea, vomiting, and diarrhea; essentially, atropine is intended to deal with the SLUDGE effects of a nerve agent exposure. Atropine dosing is guided by the patient's clinical presentation and should be given until secretions are dry or drying and ventilation becomes less labored.

2-PAM, by contrast, does not reverse muscarinic effects on glands and smooth muscles. Instead, this medication's main goal is to decrease muscle twitching, improve muscle strength, and allow the patient to breathe better, but it has little effect on the muscarinic effects described earlier.

When it comes to treating victims of nerve agent exposure, emergency responders should understand that all nerve agents "age" once they are absorbed by the body. Thus, after a certain period of time (which varies depending on the agent), the administration of the Mark 1 or DuoDote™ kit may be largely ineffective. Soman, for example, has an aging time of approximately 2 minutes. Sarin's aging time is approximately 3 to 4 hours. The other nerve agents have longer aging times. Follow local protocols before administering Mark 1 kits.

### Blistering Agents

Two chemical agents are generally classified as blistering agents, so called because contact with these chemicals causes the skin to blister.

- Sulfur mustard (H) is a clear, yellow, or amber, oily liquid with a faint sweet odor of mustard or garlic. It vaporizes slowly at temperate climates and may be dispersed in an aerosol form.
- Lewisite (L) is an oily, colorless-to-dark-brown liquid with an odor of geraniums.

Blistering agents (also known as vesicants) produce harmful and painful burns and blisters with even minimal exposure to the skin Figure 6-16. The major difference between sulfur mustard and lewisite is that lewisite causes pain immediately upon contact with the skin, whereas the signs and symptoms from exposure to sulfur mustard may not appear for several

Figure 6-16 Typical effects of blistering agents.

hours. The patient will complain of burning at the site of the exposure, the skin will redden, and blisters will appear. The eyes may also itch, burn, and turn red. Both of these vesicants can cause significant—and possibly fatal—respiratory damage.

### Pulmonary Agents

Pulmonary agents (choking agents) cause severe damage to the lungs and lead to asphyxia. Two chemicals that might be used as pulmonary agents in terrorist attacks are phosgene and chlorine. Both of these agents were used extensively as weapons in World War I, and both have several industrial uses.

Phosgene and chlorine are heavier than air, so they tend to settle in low areas. Thus subways, basements, and sewers are prime areas for these agents to accumulate.

Exposure to high concentrations of phosgene or chlorine will immediately irritate the eyes, nose, and upper airway. Within hours, the exposed individual will begin to develop pulmonary edema (fluid in the lungs). Individuals who are exposed to lower concentrations may not exhibit any initial symptoms but can still experience respiratory damage.

Although neither agent is absorbed through the skin, both phosgene and chlorine can cause skin burns on contact. Decontamination should consist of removing exposed individuals from the area and flushing the skin with water.

**Responder Tips**

**Bacteria**
Single-cell microscopic organisms with a nucleus, cellular guts, and cell wall.
May form a spore.
Examples: anthrax, plague, tularemia.

**Virus**
Submicroscopic agent; protein coated with DNA or RNA.
Require host to live and reproduce.
Examples: smallpox, viral hemorrhagic fever (VHF).

### Blood Agents

Blood agents, such as cyanide, interfere with the utilization of oxygen by the cells of the body. As mentioned earlier, cyanide compounds are highly toxic poisons that can cause death within minutes of exposure. The most commonly encountered cyanide compounds are hydrogen cyanide and cyanogen chloride, both of which have legitimate uses in industry.

Cyanide can be either inhaled or ingested. Historically, the gaseous form was used as a means of carrying out the death penalty (hence the "gas chamber"). Liquid cyanide mixed with fruit punch was used in the mass suicide of 913 members of a religious cult in Guyana in 1978.

The symptoms associated with cyanide exposure appear quickly. A person who is exposed to the gas will begin gasping for air and, if enough agent is inhaled, the skin may begin to appear red. Seizures are also possible.

### Indicators of Chemical Agents

As discussed in Chapter 3, indicators of possible criminal or terrorist activity involving chemical agents may vary depending on the complexity of the operation. Sometimes protective equipment such as rubber gloves, chemical suits, and respirators may be evident. Chemical containers of various shapes and sizes may also be present. Glass containers are very prevalent. The chemicals themselves may provide unexplained odors that are out of character for the surroundings, and residual chemicals (liquid, powder, or gas form) may be found in the area. Additionally, the presence of dead or dying vegetation and dead animals in the immediate vicinity may indicate the presence of chemical weapons. Chemistry books or other reference materials may be seen, as well as materials that are used to manufacture chemical weapons (such as scales, thermometers, or torches).

### Protection from Chemical Agents

The most common dispersal method for chemical agents is releasing the agent into the air. Agents released outdoors will follow wind currents; agents released inside structures will be dispersed through a building's air circulation system. Some chemical agents have distinctive odors. Hence, if any unusual odor is noted at an emergency scene, emergency responders must either leave the area immediately or don PPE, including self-contained breathing apparatus (SCBA) Figure 6-17 ›.

It is never sufficient to rely on odor to determine the presence of a chemical agent. Instead, definitive detection and identification of a chemical agent require the activation of a well-trained hazardous materials team.

## Biological Agents

Biological agents are organisms that cause disease and attack the body. They include bacteria, viruses, and toxins. Some of these organisms can live in the ground for years; others are rendered harmless after being exposed to sunlight for only a short period of time. The highest potential for infection is through inhalation, although some biological agents can be absorbed, injected through the skin, or ingested. The effects of a biological agent depend on the specific organism or toxin, the

Figure 6-17 If an unusual odor is reported at the scene, responders must don full PPE including SCBA.

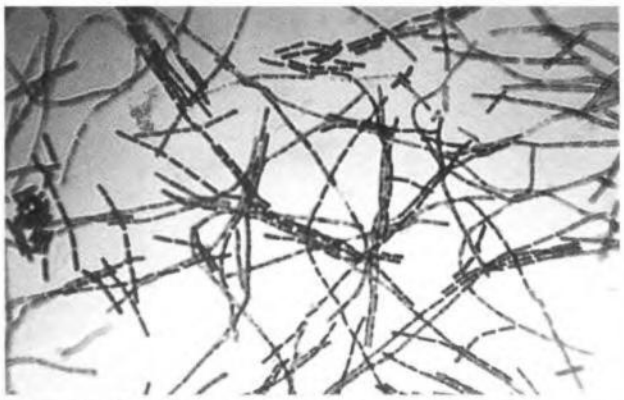

Figure 6-18 Anthrax spores can be dispersed in a variety of ways.

dose, and the route of entry. Most experts believe that a biological weapon would probably be spread by a device similar to a garden sprayer or crop-dusting plane.

Some of the diseases caused by biological agents, such as smallpox and pneumonic plague, are contagious and can be passed from person to person. Doctors are concerned about the use of contagious diseases as weapons, because the resulting epidemic could overwhelm the healthcare system. Experts have different opinions about how difficult it would be to infect large numbers of people with one of these naturally occurring organisms. Because of their **incubation period**, people would not begin to show signs of being infected until 2 to 17 days after exposure to these organisms.

### Anthrax

Anthrax is an infectious disease caused by the bacterium *Bacillus anthracis*. These bacteria are typically found around farm animals such as cows and sheep. For use as a weapon, the bacteria must be cultured to develop anthrax spores. The spores, in powdered form, can then be dispersed in a variety of ways Figure 6-18 ▸. Approximately 8000 to 10,000 spores are typically required to cause an anthrax infection. Spores infecting the skin cause cutaneous anthrax, ingested spores cause gastrointestinal anthrax, and inhaled spores cause inhalational anthrax.

The threat posed by anthrax-related terrorism is quite real. In 2001, four letters containing anthrax were mailed to locations in New York City; Boca Raton, Florida; and Washington, D.C. Five people died after being exposed to the contents of these letters, including two postal workers who were exposed as the letters passed through postal sorting centers. Several major government buildings had to be shut down for months to be decontaminated. These incidents followed shortly after the terrorist attacks of September 11, 2001, and they caused tremendous public concern. In the wake of these incidents, emergency personnel had to respond to thousands of incidents involving suspicious packages and citizens who believed that they might have been exposed to anthrax.

Today, tests are available that hazardous materials teams can perform in the field to determine whether the threat of anthrax is legitimate. The gold standard to positively identify anthrax, however, is not a field test. Anthrax must be cultured in a lab, by qualified microbiologists, to be positively identified. Your agency should have established procedures for handling suspicious powders and getting samples to a qualified laboratory.

Anthrax has an incubation period of two to six days. The disease can be successfully treated with a variety of antibiotics if it is diagnosed early enough.

### Plague

Plague is caused by *Yersinia pestis*, a bacterium that is commonly found on rodents. These bacteria are most often transmitted to humans by fleas that feed on infected animals and then bite humans.

Two main forms of plague are distinguished: bubonic and pneumonic. Individuals who are bitten by fleas generally develop bubonic plague, which attacks the lymph nodes Figure 6-19 ▸. Pneumonic plague can be contracted by inhaling the bacterium.

*Yersinia pestis* can survive for weeks in water, moist soil, or grains. These bacteria might also be cultured for distribution as a weapon in aerosol form. Inhalation of the aerosol form would put the target population at risk for pneumonic plague.

The incubation period for the plague ranges from 2 to 6 days. This disease can be treated with antibiotics.

Figure 6-19 A bubo—one of the symptoms of the plague—consists of a swollen, painful lymph node.

Figure 6-20 Smallpox is a highly contagious disease with a mortality rate of approximately 30 percent. (Courtesy of Centers for Disease Control and Prevention.)

### Smallpox

Smallpox is a highly infectious and often fatal disease caused by *Variola*, a virus; it kills approximately 30 percent of all persons who become infected with this pathogen. Smallpox first presents with small red spots or as a rash in the mouth. The rash then progresses to the face and then to the arms and legs, and farther outward to the hands and feet. Smallpox lesions are unique in that all lesions appear to be in the same stage of development at the same time. In contrast, in chickenpox, the lesions are in different stages of development across the body. Additionally, smallpox lesions can be found on the palms of the hands and the soles of the feet, whereas chickenpox lesions are seldom found on the palms and/or soles of the feet.

Although smallpox was once routinely encountered throughout the world, by 1980 it had been successfully eradicated as a public health threat through the use of an extremely effective vaccine. Officially, two countries (the United States and Russia) have maintained cultures of the disease for research purposes. It is possible, however, that international terrorist groups may have acquired the virus.

The smallpox virus could potentially be dispersed over a wide area in an aerosol form. Infecting a small number of people could lead to a rapid spread of the disease throughout a targeted population, given smallpox's highly contagious nature: The disease is easily spread by direct contact, droplet, and airborne transmission. Patients are considered highly infectious and should be quarantined until the last scab has fallen off Figure 6-20 ›. The incubation period for smallpox is between 4 and 17 days (average = 12 days).

Currently there are millions of people who have never been vaccinated for the disease, and millions more have reduced immunity because decades have passed since their last immunization.

### Indicators of Biological Agents

As discussed in Chapter 3, indicators of the presence of biological agents are somewhat similar to the indicators of chemical agents. Production or containment equipment may be present, including equipment such as Petri dishes, vented hoods, Bunsen burners, pipettes, microscopes, and incubators. Microbiology or biology textbooks or reference manuals may be present. Containers used to transport biological agents may be observed, including metal cylindrical cans or plastic boxes or bags. Personal protective equipment such as respirators, chemical or biological suits, and latex gloves may be present. Excessive amounts of antibiotics may be present as a means to protect personnel working with the agents. Other potential signs of biological agents may include abandoned spray devices and unscheduled or unusual sprays being disseminated (especially outdoors at night). Finally, personnel working in the area of the lab may exhibit symptoms consistent with the biological weapons with which they are working.

### Protection from Biological Agents

It is unlikely that fire fighters or other emergency responders would immediately recognize that a biological weapon had been released in their communities, in large part because of these agents' incubation period—that is, the lag between the actual infection and the appearance of symptoms. The signs and symptoms of a biological agent attack would typically manifest over a period of days after the exposure. If left untreated, many of these diseases will cause death in a large proportion of those infected.

The Centers for Disease Control and Prevention (CDC) and/or area hospitals would typically be the first to recognize the situation, after identifying significant numbers of people arriving at their facilities with similar symptoms. Multiple medical calls with patients exhibiting similar symptoms could provide a clue about the use of a biological weapon, especially if the location is considered to be a potential target.

Fire fighters or emergency responders treating people who may have been exposed to a biological agent should follow the recommendations of their departments regarding universal precautions (protective measures for use in dealing with objects, blood, body fluids, or other potential exposure risks of communicable diseases). These measures include wearing gloves, masks with high-efficiency particulate air (HEPA)

filtration, eye protection, and surgical gowns when treating patients.

Emergency responders who exhibit flu-like symptoms after a potential terrorist incident should seek medical care immediately. It is important that responders report any possible exposure to department officials. Postincident actions may include medical screening, testing, or vaccinations.

## Radiological Agents

A third type of agent that may potentially be used by terrorists is radiation. The most probable scenarios involve the use of a variety of approaches to disperse radiological agents and contaminate an area with radioactive materials. This threat is very different from that posed by a nuclear detonation.

### Radiation

Radioactive materials release energy in the form of electromagnetic waves or energy particles. The resulting radiation cannot be detected by the normal senses of smell and taste. Several instruments have been developed that can detect the presence of radiation and measure dose rates. All responders should become familiar with the radiation detectors used by their departments. Do not enter any place that may contain radiation unless you have been trained in measuring radiation, have a working radiation detector, and are properly protected.

Three types of radiation exist: alpha particles, beta particles, and gamma rays.

- Alpha particles quickly lose their energy and, therefore, can travel only 1 to 2 inches from their source. Clothing or a sheet of paper can stop this type of energy. If ingested or inhaled, alpha particles can damage a number of internal organs.
- Beta particles are more powerful, capable of traveling 10 to 15 feet. Heavier materials such as metal, plastic, and glass can stop this type of energy. Beta radiation can be harmful to both the skin and eyes, and ingestion or inhalation will damage internal organs.
- Gamma radiation can travel significant distances, penetrate most materials, and pass through the body. Gamma radiation is the most destructive to the human body. The only materials with sufficient mass to stop gamma radiation are concrete, earth, and dense metals such as lead.

### Effects of Radiation

Symptoms of low-level radioactive exposure might include nausea and vomiting. Exposure to high levels of radiation can also cause vomiting and digestive system damage within a short time. Other symptoms of high-level radiation exposure include bone marrow destruction, nerve system damage, and radioactive skin burns. An extreme exposure may cause death rapidly; more typically, it takes time before the signs and symptoms of radiation poisoning become obvious. As the effects progress over the years, a prolonged spiral into death caused by leukemia or carcinoma may occur.

A contaminated person will have radioactive materials on the exposed skin and clothing. In severe cases, the contamination could penetrate to the internal organs of the body. For this reason, decontamination procedures are required to remove the radioactive materials. Decontamination must be complete and thorough because the situation could escalate rapidly if this procedure is inadequate. Specifically, the contamination could quickly spread to ambulances, hospitals, and other locations where contaminated individuals or items are transported.

Radioactive materials both expose rescuers to radiation injury and continue to affect the exposed person. Anyone who comes in contact with a contaminated person must be protected by appropriate PPE and shielding, depending on the particular contaminant. Rescuers and medical personnel must all be decontaminated after handling a contaminated person because the only way to know whether radiation is present on individuals' bodies or clothing is to use radiation detectors.

A person can be exposed to radiation without coming into direct contact with a radioactive material through inhalation, skin absorption, or ingestion. A person can also be injured by exposure to radiation, without being contaminated by the radioactive material itself. Someone who has been exposed to radiation, but who has not been contaminated by radioactive materials, requires no special handling.

There are three ways to limit exposure to radioactivity:

- Keep the **time** of the exposure as short as possible.
- Stay as far away **(distance)** from the source of the radiation as possible.
- Use **shielding** to limit the amount of radiation absorbed by the body.

In addition, do not enter any area that might contain radiation until trained personnel have assessed the radiation level using approved detection devices. If radioactive contamination is suspected, everyone who enters the area should be equipped with a personal dosimeter to measure the amount of radioactive exposure Figure 6-21.

Rescue attempts should be made only by properly trained and equipped personnel, each of whom must carry an approved radiation monitor to measure the amount of radiation present. Chapter 2 provides a more thorough review of radiation and its potential health effects and Chapter 14 provides an overview of radiation detection devices.

Figure 6-21 A personal dosimeter measures the amount of radioactive exposure received by an individual.

### Indicators of Radiological Agents

Indicators of radiological agents typically include production or containment equipment, such as lead or stainless steel containers (with nuclear or radiological labels), and equipment that may be used to detonate the radioactive source, such as containers (e.g., pipes), caps, fuses, gunpowder, timers, wire, and detonators. Personal protective equipment present may include radiological protective suits and respirators. Radiation monitoring equipment such as Geiger counters or radiation pagers may be evident as well. Personnel working around the radiological agents may exhibit exposure symptoms such as burns or experience difficulty breathing.

### The Dirty Bomb

In recent years, the radiation dispersal device (RDD) or "dirty bomb" has emerged as a source of serious concern in terms of terrorism. An RDD has been described as "any device that causes the purposeful dissemination of radioactive material across an area without a nuclear detonation." Packing radioactive material around a conventional explosive device could contaminate a wide area, with the size of the affected area ultimately depending on the amount of radioactive material and the power of the explosive device.

To limit this threat, radioactive materials, even in small amounts, are kept secure and protected. Such materials are widely used in industry and health care however, particularly in conjunction with X-ray machines. A terrorist could potentially construct a dirty bomb with just a small quantity of stolen radioactive material.

Security experts are also concerned that a large explosive device, such as a truck bomb, might potentially be detonated near a nuclear power plant. Such an explosion could damage the reactor containment vessel and release radioactive material into the atmosphere.

## Operations

Responding to a terrorist incident inevitably puts emergency personnel at risk. Although responders must ensure their own safety at every incident, a terrorist incident may carry an extra dimension of risk. Because the terrorist's objective is to cause as much harm as possible, emergency responders are just as likely to be targets as are ordinary civilians.

In most cases, the first emergency units will not be dispatched for a known WMD or terrorist incident. Rather, the initial dispatch report might cite an explosion, a possible hazardous materials incident, a single person with difficulty breathing, or multiple victims with similar symptoms. Emergency responders will usually not know that a terrorist incident has occurred until personnel on the scene begin to piece together information gained from their own observations and from interviews with witnesses.

If appropriate precautions are not taken, the initial responders may find themselves in the middle of a dangerous situation before they realize what has happened. For this reason, initial responders should take note of any factors that suggest the possibility of a terrorist incident and immediately implement appropriate procedures. The possibility of a terrorist incident should be considered when responding to any location that has been identified as a potential terrorist target. It could be difficult to determine the true nature of the situation until a scene size-up is conducted.

## Initial Actions

Responders should approach a known or potential terrorist incident just as they would a hazardous materials incident. If possible, apparatus and personnel should approach the scene from a position that is uphill and upwind. Emergency responders should don PPE, including SCBA. Later-arriving units should be staged an appropriate distance away from the incident.

The first units to arrive should establish an outer perimeter to control access to and from the scene. They should deny access to all persons except emergency responders, and they should prevent potentially contaminated individuals from leaving the area before they have been decontaminated. The perimeter must completely surround the affected area, with the goal being to keep people who were not initially involved from becoming additional victims. This operation sounds quite orderly while you are reading this book, but rest assured that a real-world scene will be chaotic; there will be widespread panic and you will probably be overwhelmed. It will take some time and many more responders before you get a handle on the scene. Expect this kind of tumultuous environment if the incident is significant.

Incident command should be established in a safe location, which could be as far as 3000 feet away from the actual incident scene. The incident command post must be set up outside the area of possible contamination and beyond the distance where a secondary device may be planted. The initial task should be to determine the nature of the situation, the types of hazards that could be encountered, and the magnitude of the problems that must be faced.

An initial reconnaissance (recon team) team should be sent out to quickly examine the involved area and to determine how many people are involved. Proper use of PPE, including SCBA, is essential for the recon team, and the initial survey must be conducted very cautiously, albeit as rapidly as possible. The possibility that chemical, biological, or radiological agents are involved cannot be ruled out until qualified personnel with appropriate instruments and detection devices have surveyed the area. Responders should begin their reconnaissance mission from a safe distance, working inward toward the scene, while taking care not to touch any liquids or solids or to walk through pools of liquid. Emergency responders who become contaminated must not leave the area until they have been decontaminated.

A process of elimination may be required to determine the nature of the situation. Occupants and witnesses should be asked if they observed any unusual packages or detected any strange odors, mists, or sprays. The presence of a large number of casualties, who have no outward signs of trauma, could indicate a possible chemical agent exposure. In such a case, victims' symptoms might include trouble breathing, skin irritations, or seizures.

A visible vapor cloud would be another strong indicator of a chemical release. Such a release could have occurred as the result of either an accident or a terrorist attack. The presence of dead or dying animals, insects, or plant life might also point to a chemical agent release as the culprit.

When approaching the scene of an explosion, responders should consider the possibility of a terrorist bombing incident and remain vigilant for secondary explosive devices. They should note any suspicious packages and notify the IC immediately. Responders who have not been specially trained should never approach a suspicious object. Instead, EOD personnel should examine any suspicious articles and disable them.

The guidelines presented in this section are general recommendations, of course. You must also rely on your agency's standard operating procedures, your training, and your experience to take the appropriate actions. A terrorist event may never happen in your jurisdiction—but if it does, it will require every bit of skill you have to operate safely and effectively.

Figure 6-22 An EOC is set up in a predetermined location for large-scale incidents.

## Interagency Coordination

If a terrorist incident is suspected, the IC, if he or she is not already a member of a law enforcement agency, should consult immediately with local law enforcement officials. If there are casualties, or if a mass-casualty situation is evident, the IC should notify area hospitals and activate the mass-casualty emergency medical plan (if one exists). Typically, local hospitals will begin to conduct an open-bed count and communicate with other hospitals about the availability of specialized medical services. Technical rescue teams should be requested to evaluate structural damage and initiate rescue operations.

State emergency management officials should be notified as soon as possible. This will help ensure a quick response by both state and federal resources to a major incident. Regional emergency operation centers (REOCs) and state-level emergency operation centers (EOCs) may be established, depending on the severity of the incident. Large-scale search-and-rescue incidents could require the response of Urban Search and Rescue (USAR) task forces activated through the Federal Emergency Management Agency (FEMA). Medical response teams, such as Disaster Medical Assistance Teams (DMAT), may be needed for incidents involving large numbers of people.

An EOC can help to coordinate the actions of all involved agencies in a large-scale incident, particularly if terrorism is involved. The EOC is usually set up in a predetermined remote location and is staffed by experienced command and staff personnel Figure 6-22 ▸. The IC, who remains at the scene of the incident, should provide detailed situation reports to the EOC and request additional resources as needed.

Responders must remember that a terrorist incident is also a crime scene. To avoid destroying important evidence that could lead to a conviction of those responsible for perpetrating the attack, responders should not disturb the scene any more than is necessary. Where possible, law enforcement personnel should be consulted prior to overhaul and before the removal of any material from the scene. Responders should also realize that one or more terrorists could be among the injured. Be alert for threatening behavior, and make note of anyone who seems determined to leave the scene. Chapter 10, Mission-Specific Competencies: Evidence Preservation and Sampling, provides more information on this topic.

## Decontamination

Everyone who is exposed to chemical, biological, or radiological agents must be decontaminated to remove or neutralize any chemicals or substances on their bodies or clothing. Decontamination should occur as soon as possible to prevent further absorption of a contaminant and to reduce the possibility of spreading the contamination. Likewise, equipment must be decontaminated before it leaves the scene. Chapter 8, Mission-Specific Competencies: Technical Decontamination and Chapter 9, Mission-Specific Competencies: Mass Decontamination, explains decontamination procedures in detail.

The perimeter established for the incident response must fully surround the area of known or suspected contamination. Every effort must be made to avoid contaminating any additional areas, particularly hospitals and medical facilities. Qualified personnel must monitor the perimeter with instruments or detection devices to ensure that contaminants are not spread.

Standard decontamination procedures usually involve processing of individuals through a series of stations. At each station, clothing and protective equipment are removed and the individual is cleaned. Although some contaminants require only soap and water for their removal, elimination of chemical and biological agents may require the use of special neutralizing solutions. Because of the chemical reaction that takes place during neutralization, this may not be the preferred method of decontamination.

A terrorist incident that results in a large number of casualties may require a somewhat different decontamination process. Special procedures for **mass decontamination** have been devised for incidents involving large numbers of people. These

Figure 6-23 Mass-decontamination procedures may be required to handle large groups of contaminated victims.

Figure 6-24 Patients should be decontaminated before they are placed in triage and treatment areas.

procedures use master stream devices from engine companies and aerial apparatus to create high-volume, low-pressure showers. This approach allows large numbers of people to be decontaminated rapidly Figure 6-23 ▲.

## Mass Casualties

A terrorist or WMD incident may result in a large number of casualties—hundreds or thousands of injuries in some scenarios. Special mass-casualty plans are essential to manage this type of situation, which would quickly overwhelm the normal capabilities of most emergency response systems. Mass-casualty plans typically require resources from multiple agencies to handle large numbers of patients efficiently. A terrorist incident, however, might potentially involve several additional complications and considerations, including the possibility of contamination by chemical, biological, or radiological agents. The mass-casualty plan must be expanded to address these problems.

If contamination is suspected, the plan must ensure that it does not spread beyond a defined perimeter. In some cases, patients may need to be decontaminated as they are moved to the triage and treatment areas so as to keep these areas free of contaminants Figure 6-24 ▶. In other cases, the triage and treatment areas may be considered contaminated zones. In this scenario, patients would be decontaminated before they are transported from the scene.

During the early stages of an incident, it may be difficult to determine which agent was used and, therefore, which treatment and decontamination procedures are appropriate. In such a case, it may be necessary to quarantine exposed individuals within the area that is assumed to be contaminated until further analysis is done. Field categorization of the substance may involve performing a series of chemical tests on a sample of the agent.

Do not withhold decontamination when life safety is paramount: Default to a water or soap-and-water decontamination so that medical treatment can be rendered promptly. The specific actions to be taken will always be dictated by your size-up of the situation and the most prudent course of action based on the nature of the contaminant and the circumstances under which it was released.

## Additional Resources

As previously mentioned, terrorist incidents will likely result in a massive response by local, state, and federal government agencies. The FBI is the lead agency for crisis management, and FEMA is the lead agency for consequence management during a terrorist incident. Nevertheless, these roles are not cut-and-dried; in fact, there is a gray area where they may intersect.

Several federal agencies have specific responsibilities related to terrorist incidents, including the Department of Homeland Security. The Homeland Security Advisory System provides guidance on protective measures when specific information to a particular sector or geographic region is received. It combines threat information with vulnerability assessments and communicates that information to public safety officials and the public.

Homeland Security Threat Advisories contain actionable information about an incident involving, or a threat targeting, critical national networks or infrastructures or key assets. They could, for example, relay newly developed procedures that, when implemented, would significantly improve security or protection. These communications could also suggest a change in readiness posture, protective actions, or response. This category of guidelines includes messages formerly named alerts, advisories, and sector notifications. Advisories are targeted to federal, state, and local governments; private-sector organizations; and international partners.

Homeland Security Information Bulletins communicate information of interest to U.S. critical infrastructures that does not meet the timeliness, specificity, or significance thresholds

of warning messages. Such information may include statistical reports, periodic summaries, incident response or reporting guidelines, common vulnerabilities and patches, and configuration standards or tools. It also may include preliminary requests for information. Bulletins are targeted to federal, state, and local governments; private-sector organizations; and international partners.

The Department of Homeland Security's color-coded threat-level system is used to communicate with public officials and the public so that protective measures can be implemented to reduce the likelihood or impact of an attack Figure 6-25. Raising the threat condition (i.e., changing the color code) has economic, physical, and psychological effects on the United States, so the Homeland Security Advisory System may place specific geographic regions or industry sectors on a higher alert status than other regions or industries, based on specific threat information.

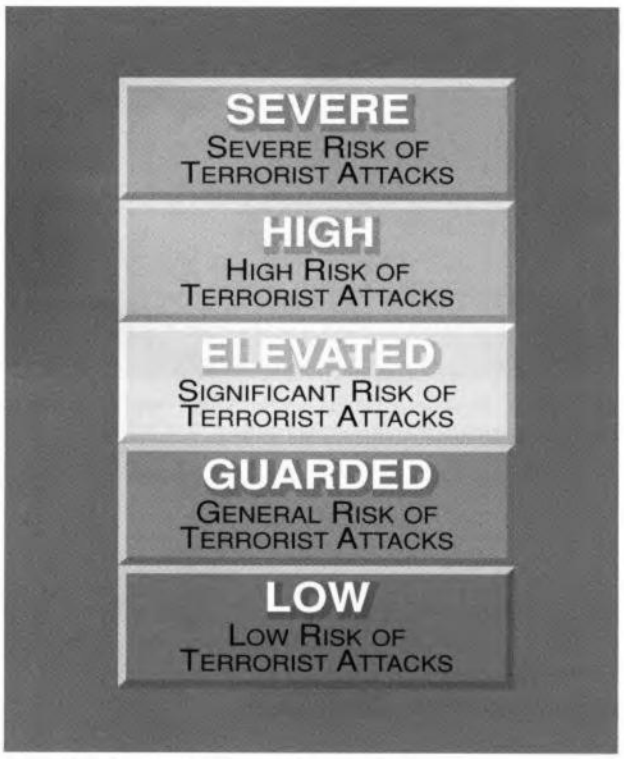


Figure 6-25 Color-coded threat-level system.

# Wrap-Up

## Chief Concepts

- Terrorism is the unlawful use of violence or threats of violence to intimidate or coerce a government, the civilian population, or any segment thereof, to further political or social objectives. This broad definition encompasses a wide range of acts committed by different groups for different purposes.
- The goal of terrorism is to produce feelings of fear in a population or a group.
- Terrorism can occur in any community, so it is essential that responders be aware of all potential targets in their area.
- Terrorists can turn ordinary objects into weapons.
- Secondary devices are intended to explode some time after the initial device detonates.
- Weapons of mass destruction include chemical, biological, and radiological agents, as well as conventional weapons and explosives.
- As part of the response to a potential terrorism incident, it is important to be able to identify which type of agent is involved.
- When dealing with a potential terrorist-related incident, responders should establish a staging area at a safe distance from the scene and follow the direction of the incident commander.
- Interagency coordination is an important part of responding to a terrorist event.

## Hot Terms

Agroterrorism The intentional act of using chemical or biological agents against the agricultural industry or food supply.

Alpha particles A type of radiation that quickly loses energy and can travel only 1 to 2 inches from its source. Clothing or a sheet of paper can stop this type of energy. Alpha particles are not dangerous to plants, animals, or people unless the alpha-emitting substance has entered the body.

Ammonium nitrate fertilizer and fuel oil (ANFO) An explosive made of commonly available materials.

Anthrax An infectious disease spread by the bacterium *Bacillus anthracis*; typically found around farms, infecting livestock.

Beta particles A type of radiation that is capable of traveling 10 to 15 feet from its source. Heavier materials, such as metal, plastic, and glass, can stop this type of energy.

Biological agents Disease-causing bacteria, viruses, and other agents that attack the human body.

Blistering agents A chemical that causes the skin to blister. Also known as a vesicant.

Blood agent Chemicals that interfere with the utilization of oxygen by the cells of the body. Cyanide is an example of a blood agent.

Chlorine A yellowish gas that is approximately 2.5 times heavier than air and slightly water soluble. Chlorine has many industrial uses. It damages the lungs when inhaled; it is a choking agent.

Choking agent A chemical designed to inhibit breathing, and typically intended to incapacitate rather than kill its victims.

Color-coded threat-level system The Department of Homeland Security's system for communicating with public officials and the public so that protective measures can be implemented to reduce the likelihood or impact of a terrorist attack.

Cyanide A highly toxic chemical agent that prevents cells from using oxygen.

Cyberterrorism The intentional act of electronically attacking government or private computer systems.

Ecoterrorism Terrorism directed against causes that radical environmentalists think would damage the earth or its creatures.

Explosive ordnance disposal (EOD) personnel Personnel trained to detect, identify, evaluate, render safe, recover, and dispose of unexploded explosive devices.

Forward staging area A strategically placed area, close to the incident site, where personnel and equipment can be held in readiness for rapid response to an emergency event.

Gamma radiation A type of radiation that can travel significant distances, penetrating most materials and passing through the body. Gamma rays are the most destructive type of radiation to the human body.

Homeland Security Information Bulletins Federally issued guidelines that communicate information of interest to U.S. critical infrastructures that does not meet the timeliness, specificity, or significance thresholds of warning messages.

Homeland Security Threat Advisories Federally issued guidelines that contain actionable information about

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an incident involving, or a threat targeting, critical national networks or infrastructures or key assets.

Improvised explosive device (IED) An explosive or incendiary device that is fabricated in an improvised manner.

Incubation period The time period between the initial infection by an organism and the development of symptoms by a victim.

Lewisite A blister-forming agent that is an oily, colorless-to-dark brown liquid with an odor of geraniums.

Mark 1 Nerve Agent Antidote Kit (NAAK) A military-developed kit containing antidotes that can be administered to victims of a nerve agent attack.

Mass decontamination The physical process of reducing or removing surface contaminants from large numbers of victims in potentially life-threatening situations in the fastest time possible.

Muscarinic effects Effects such as runny nose, salivation, sweating, bronchoconstriction, bronchial secretions, nausea, vomiting, and diarrhea.

Nerve agent A toxic substance that attacks the central nervous system in humans.

Personal dosimeter A device that measures the amount of radioactive exposure incurred by an individual.

Phosgene A chemical agent that causes severe pulmonary damage.

Pipe bomb A device created by filling a section of pipe with an explosive material.

Plague An infectious disease caused by the bacterium *Yersinia pestis*, which is commonly found on rodents.

Pulmonary agent Chemicals that cause severe damage to the lungs and lead to asphyxia. Chlorine and phosgene are examples. Pulmonary agents may also be referred to as choking agents.

Radiation dispersal device (RDD) Any device that causes the purposeful dissemination of radioactive material without a nuclear detonation; a dirty bomb.

Radiological agents Materials that emit radioactivity (the spontaneous decay or disintegration of an unstable atomic nucleus accompanied by the emission of radiation).

Sarin A liquid nerve agent that is primarily a vapor hazard.

Secondary device An explosive or incendiary device designed to harm emergency responders who have responded to an initial event.

Smallpox A highly infectious disease caused by the *Variola* virus.

Soman A nerve gas that is both a contact and a vapor hazard; it has the odor of camphor.

Sulfur mustard A clear, yellow, or amber oily liquid with a faint sweet odor of mustard or garlic that may be dispersed in an aerosol form. It causes blistering of exposed skin.

Tabun A nerve agent that disables the chemical connections between nerves and targets organs.

Terrorism As defined by the Code of Federal Regulations, the unlawful use of force and violence against persons or property to intimidate or coerce a government, the civilian population, or any segment thereof, in furtherance of political or social objectives.

Triage The process of sorting victims based on the severity of their injuries and medical needs to establish treatment and transportation priorities.

Universal precautions Procedures for infection control that treat blood and certain bodily fluids as capable of transmitting bloodborne diseases.

V-agent (VX) A nerve agent, principally a contact hazard; an oily liquid that can persist for several weeks.

Weapons of mass destruction (WMD) Weapons whose use is intended to cause mass casualties, damage, and chaos. The NFPA includes the use of WMD in its definition of *hazardous materials*.

# Responder *in Action*

You are on duty when the threat level for possible terrorist activity is raised to "Orange." The paramedic supervisor reviews the department's standard operating procedures for potential terrorist incidents with your ambulance crew and tells you to double-check all of the medical supplies and hazardous materials equipment that are carried on your apparatus.

During the afternoon rush hour, an engine company from the local volunteer fire company and your ambulance respond to a report of an unconscious person at a bus station. En route, the dispatcher advises you that there are now several patients feeling ill at this location.

1. Which of the following factors would cause you to suspect that this is a terrorist incident?
   - **A.** "Orange" terrorist threat level
   - **B.** Bus station during rush hour
   - **C.** Multiple patients with similar symptoms
   - **D.** All of the above
2. The bus station is a confusing scene, with many passengers entering and exiting the structure. You see several individuals sitting on the sidewalk close to the entrance. They look disoriented and confused. What is your first priority?
   - **A.** Without chemical-protective gear, enter the bus station to search for additional victims.
   - **B.** Immediately transport all patients to the closest hospital.
   - **C.** Establish a perimeter around the scene and prevent anyone from entering the bus station.
   - **D.** Set up a fan to blow fresh air into the bus entrance.
3. A witness tells you that several individuals came out of the bus station complaining of burning eyes, a choking sensation, nausea, and dizziness. The witness does not have any information about the situation inside the station. Which actions should be taken now?
   - **A.** Establish an incident command post and request additional units.
   - **B.** Advise the bus authority to prevent the discharge of any additional passengers at this station.
   - **C.** Move patients away from the bus entrance and establish a treatment area.
   - **D.** All of the above.
4. As hazardous materials teams arrive, one of the first assignments is to enter the bus station to rescue anyone who is still inside and determine if there are any additional patients. The crew that is assigned to enter the station should wear
   - **A.** latex gloves and face masks.
   - **B.** firefighting PPE and SCBA.
   - **C.** Level B hazardous materials ensembles.
   - **D.** Level A hazardous materials ensembles.
5. Two additional patients who are coughing and have extremely red, watery eyes exit from the station. These individuals report that they observed a canister on the floor of the station. A fine, white, powdered residue surrounded the canister. The incident commander should issue the following order:
   - **A.** Order an engine company to begin decontaminating the patients.
   - **B.** Order ambulances to transport all of the patients to a nearby hospital immediately.
   - **C.** Send the crew back into the station to retrieve the canister and bring it outside for close examination.
   - **D.** Assign a hazardous materials team to attempt to identify the substance.

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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.

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.

**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

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:

**T**hermal
**R**adiological
**A**sphyxiating
**C**hemical
**E**tiological/biological
**M**echanical
**P**sychogenic

## 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.

| Chemical Name | Concentration | Breakthrough Time | Permeation Rate |
|---|---|---|---|
| | (%) | Normalized (min) | (µg/cm2/min) |
| 1,1,2,2-TETRACHLOROETHANE | 95+ | >480 | 0.0005 |
| 1,1,2-TRICHLOROETHANE | 95+ | >480 | <0.01 |
| 1,3-DICHLOROACETONE (40°C) | 95+ | >480 | <0.1 |
| 1,4-DIOXANE | 95+ | >480 | <0.05 |
| 1,6-HEXAMETHYLENEDIAMINE | 95+ | >480 | <0.01 |
| 2,2,2-TRICHLOROETHANOL | 95+ | >480 | <0.01 |
| 2,2,2-TRIFLUOROETHANOL | 95+ | >480 | <0.001 |
| 2,3-DICHLOROPROPENE | 95+ | >480 | <0.08 |
| 2-CHLOROETHANOL | 95+ | >480 | <0.008 |
| 2-METHYLGLUTARONITRILE | 87 | >480 | <0.1 |
| 2-PICOLINE | 95+ | 46 | 48 |
| 3,4-DICHLOROANILINE | 95+ | 264 | 2.4 |
| 3-PICOLINE | 95+ | 11 | 22 |
| 4,4'METHYLENE BIS(2-CHLOROANILINE) | 95+ | >480 | <0.1 |
| ACETALDEHYDE | 95+ | >480 | <0.01 |
| ACETIC ACID | 95+ | 339 | 1.3 |
| ACETIC ANHYDRIDE | 95+ | >480 | <0.051 |
| ACETONE | 95+ | >480 | <0.051 |
| ACETONITRILE | 95+ | >480 | <0.01 |
| ACETYL CHLORIDE | 95+ | 181 | 2 |
| ACROLEIN | 95+ | >480 | <0.02 |
| ACRYLAMIDE | 50% in water | >480 | <0.1 |
| ACRYLIC ACID | 95+ | 270 | 1.6 |
| ACRYLONITRILE | 95+ | >480 | <0.0003 |
| ADIPONITRILE | 95+ | >480 | <0.1 |
| ALLYL ALCOHOL | 95+ | >480 | <0.1 |
| ALLYL CHLORIDE | 95+ | >480 | <0.06 |
| AMMONIA GAS | 95+ | 46 | 0.62 |
| AMMONIUM FLUORIDE | 40 | >480 | <0.01 |
| AMMONIUM HYDROXIDE | 28-30 | 160 | 4.7 |
| AMYL ACETATE | 95+ | >480 | <0.002 |
| ANILINE | 95+ | >480 | <0.1 |
| ARSINE | 95+ | >480 | <0.01 |
| BENZENE SULFONYL CHLORIDE | 95+ | >480 | <0.1 |
| BENZIDINE | 25% in Methanol | >480 | <0.01 |
| BENZONITRILE | 95+ | >480 | <0.004 |
| BENZONITRILE | 95+ | >480 | <0.004 |
| BENZOYL CHLORIDE | 95+ | >480 | <0.05 |
| BENZYL CHLORIDE | 95+ | >480 | <0.01 |
| BORON TRICHLORIDE | 95+ | >480 | <0.02 |
| BORON TRIFLUORIDE | 95+ | >480 | <0.1 |

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.

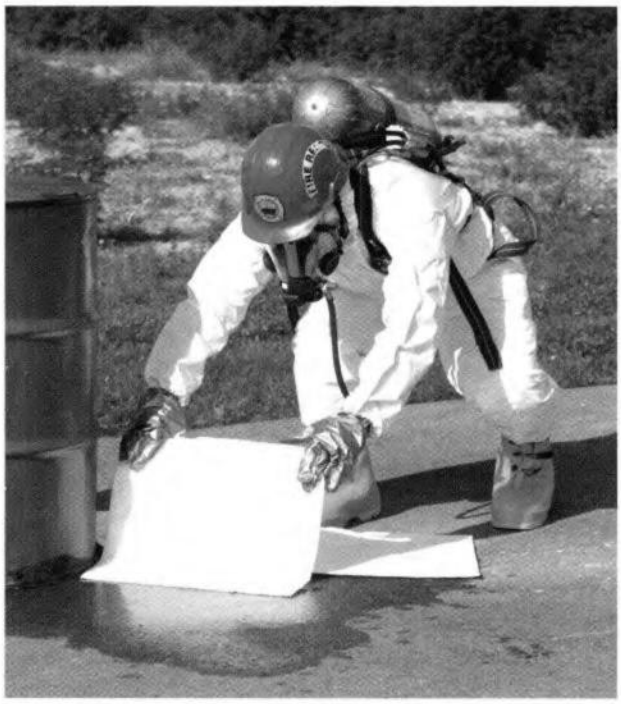


Figure 7-8 Liquid splash–protective clothing must be worn whenever there is the danger of chemical splashes.

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 ex-

posed 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)

## Skill Drill 7-1

NFPA 472, 6.2.4.1

# 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:

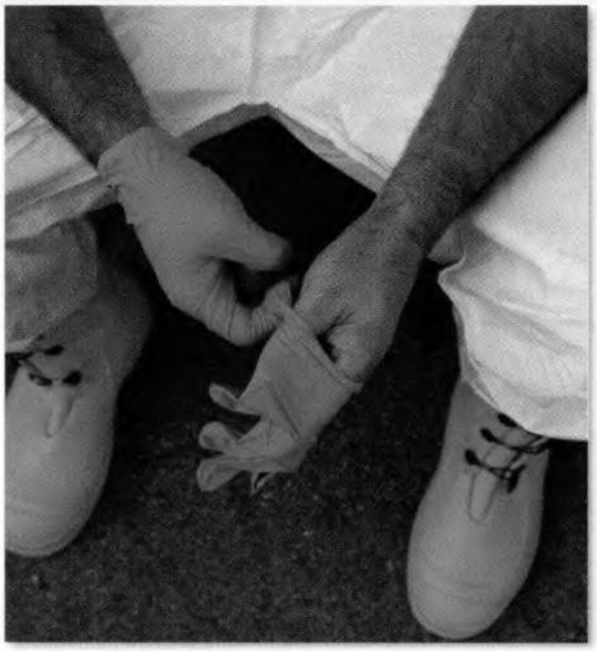
1. After completing decontamination, proceed to the clean area for suit doffing.
2. As with level B, instruct the assistant to open the chemical splash flap and suit zipper.
3. Remove the hands from the outer gloves and your arms from the sleeves.
4. Instruct the assistant to begin at the head and roll 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

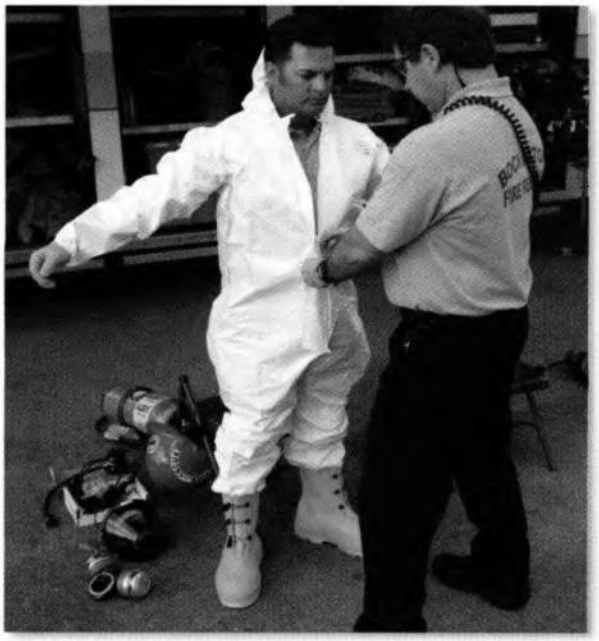
NFPA 472, 6.2.4.1

# 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 |

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*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 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."*

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.

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 prob-

lem 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 creden-

tialed 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.

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# 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.

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CHAPTER

# 11

## NFPA 472 Standard

### Competencies for Operations Level Responders Assigned Mission-Specific Responsibilities

**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

(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 [p. 244–259]

(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. 244–259]

**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. 244–259]

**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. 244–259]

**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. 244–259]

**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. 244–259]

**6.1.3** **Mandating of Competencies.** This standard shall not mandate that the response organizations perform mission-specific responsibilities. [p. 244–259]

**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. 244–259]

**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. 244–259]

**6.6** **Mission-Specific Competencies: Product Control.**

**6.6.1** **General.**

**6.6.1.1** **Introduction.**

**6.6.1.1.1** The operations level responder assigned to perform product control shall be that person, competent at the operations level, who is assigned to implement product control measures at hazardous materials/WMD incidents. [p. 244–256]

**6.6.1.1.2** The operations level responder assigned to perform product control 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), all mission-specific competencies for personal protective equipment (Section 6.2), and all competencies in this section. [p. 244–256]

**6.6.1.1.3** The operations level responder assigned to perform product control at hazardous materials/WMD incidents shall operate under the guidance of a hazardous materials technician, an allied professional, or standard operating procedures. [p. 244]

**6.6.1.1.4** The operations level responder assigned to perform product control at hazardous materials/WMD incidents shall receive the additional training necessary to meet specific needs of the jurisdiction. [p. 244–259]

**6.6.1.2** **Goal.**

**6.6.1.2.1** The goal of the competencies in this section shall be to provide the operations level responder assigned to product control at hazardous materials/WMD incidents with the knowledge and skills to perform the tasks in 6.6.1.2.2 safely and effectively. [p. 244–259]

**6.6.1.2.2** When responding to hazardous materials/WMD incidents, the operations level responder assigned to perform product control shall be able to perform the following tasks:

(1) Plan an initial response within the capabilities and competencies of available personnel, personal protective equipment, and control equipment and in accor-

dance with the emergency response plan or standard operating procedures by completing the following tasks:

(a) Describe the control options available to the operations level responder. [p. 244–251]

(b) Describe the control options available for flammable liquid and flammable gas incidents. [p. 251–256]

(2) Implement the planned response to a hazardous materials/WMD incident. [p. 244–259]

**6.6.3 Competencies—Planning the Response.**

**6.6.3.1 Identifying Control Options.** Given examples of hazardous materials/WMD incidents, the operations level responder assigned to perform product control shall identify the options for each response objective and shall meet the following requirements as prescribed by the AHJ:

(1) Identify the options to accomplish a given response objective. [p. 244–251]

(2) Identify the purpose for, and the procedures, equipment, and safety precautions associated with each of the following control techniques:

(a) Absorption [p. 245–247]

(b) Adsorption [p. 245–247]

(c) Damming [p. 246–249]

(d) Diking [p. 248–250]

(e) Dilution [p. 250]

(f) Diversion [p. 250–251]

(g) Remote valve shutoff [p. 251–252]

(h) Retention [p. 251–252]

(i) Vapor dispersion [p. 252–256]

(j) Vapor suppression [p. 252–256]

**6.6.3.2 Selecting Personal Protective Equipment.** The operations level responder assigned to perform product control shall select the personal protective equipment required to support product control at hazardous materials/WMD incidents based on local procedures (*see Section 6.2*). [p. 244–259]

**6.6.4 Competencies—Implementing the Planned Response.**

**6.6.4.1 Performing Control Options.** Given an incident action plan for a hazardous materials/WMD incident, within the capabilities and equipment provided by the AHJ, the operations level responder assigned to perform product control shall demonstrate control functions set out in the plan and shall meet the following requirements as prescribed by the AHJ:

(1) Using the type of special purpose or hazard suppressing foams or agents and foam equipment furnished by the AHJ, demonstrate the application of the foam(s) or agent(s) on a spill or fire involving hazardous materials/WMD. [p. 252–256]

(2) Identify the characteristics and applicability of the following Class B foams if supplied by the AHJ:

(a) Aqueous film-forming foam (AFFF) [p. 254–256]

(b) Alcohol-resistant concentrates [p. 254–256]

(c) Fluoroprotein [p. 254–256]

(d) High-expansion foam [p. 254–256]

(3) Given the required tools and equipment, demonstrate how to perform the following control activities:

(a) Absorption [p. 245–247]

(b) Adsorption [p. 245–247]

(c) Damming [p. 246–249]

(d) Diking [p. 248–250]

(e) Dilution [p. 250]

(f) Diversion [p. 250–251]

(g) Retention [p. 251–252]

(h) Remote valve shutoff [p. 251–252]

(i) Vapor dispersion [p. 252–256]

(j) Vapor suppression [p. 252–256]

(4) Identify the location and describe the use of emergency remote shutoff devices on MC/DOT-306/406, MC/DOT- 307/407, and MC-331 cargo tanks containing flammable liquids or gases. [p. 251–253]

(5) Describe the use of emergency remote shutoff devices at fixed facilities. [p. 251–253]

**6.6.4.2** The operations level responder assigned to perform product control shall describe local procedures for going through the technical decontamination process. [p. 259]

## Knowledge Objectives

After studying this chapter, you will be able to:

- Describe and identify the control options available to operations level responders.
- Describe and identify the control options available for flammable liquid and flammable gas incidents.
- Describe the purpose, equipment, and precautions associated with control options.
- Describe the applicability and characteristics of aqueous film-forming foam, alcohol-resistant concentrates, fluoroprotein foams, protein foams, and high-expansion foams.
- Identify the location and describe the use of emergency remote shut-off devices on MC/DOT-306/406, MC/DOT-307/407, and MC-331 cargo tanks containing flammable liquids or gases.
- Describe the recovery phase, and the transition from emergency to clean-up.

## Skills Objectives

After studying this chapter, you will be able to:

- Perform the following control activities:
  - Absorption
  - Adsorption
  - Damming
  - Diking
  - Dilution
  - Diversion
  - Retention
  - Remote valve shut-off
  - Vapor dispersion
  - Vapor suppression
- Perform the following methods of applying foam:
  - Rain-down method
  - Roll-in method
  - Bounce-off method

## You Are the Responder

Your engine company has been dispatched to assist a rescue company on the scene of a rolled-over diesel truck pulling a flatbed trailer. The trailer was carrying several lengths of large steel pipe, which are now lying on the road. The fuel tanks on the diesel truck are leaking. Upon arrival, your officer receives an assignment to protect a curbside drain located downslope from the leaking tanker. He assigns the task to you and two other fire fighters. There is a slight breeze blowing away from you, back toward the leaking tanker. The product is confirmed to be diesel fuel. The concrete roadway ahead of the spill is completely dry. You have access to three plastic shovels and several bags of loose absorbent.

1. Would full structural fire fighter's turnout gear and SCBA offer adequate protection in this situation?
2. Based on your level of training (i.e., operations 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 diesel fuel, to complete the assignment.

## Introduction

It is not uncommon for a hazardous materials incident to require some form of product control. Scenarios like the one described in the chapter-opening vignette are relatively common, as are incidents involving leaking drums, spills into waterways, and other types of releases involving flammable liquids or gases. Many of these incidents require emergency responders to intervene by shutting off valves or applying loose absorbents or various kinds of foam to mitigate the situation.

In most cases, the best course of action is to confine the problem to the smallest area possible. Confinement is the process of attempting to keep the hazardous material within the immediate area of the release. This goal can usually be accomplished by damming or diking a material, or by confining vapors to a specific area. Containment, by contrast, refers to actions that stop the hazardous material from leaking or escaping its container. Examples of containment include patching or plugging a breached container, or righting an overturned container to stop a slow leak. Sometimes, it is necessary to first stop the leak (contain), and then confine whatever has been released. In other cases, it may be impossible to stop the leak and all that can be done is to confine the hazardous material as much as possible.

There is no clear-cut sequence or single best way to handle every problem involving product control issues. You must size up the situation as you would any other problem, and employ the best methods available to handle the incident safely. When considering a control option, certain factors must be evaluated, such as the maximum quantity of material that can be released and the likely duration of the incident without intervention.

It is vital in these situations, as with any other type of release, for responders to understand the nature of the release, wear the proper level of personal protective equipment (PPE), and have all the tools and equipment—including air monitoring and detection equipment—available to accomplish the task at hand. In many cases, product control measures bring responders in close proximity to the released product. To work

### Responder Tips

Some of the mission-specific competencies described in this section are taken from competencies required of hazardous materials technicians. That does not mean, however, that operations level responders, with a mission-specific competency in product control or any other mission-specific competency, are replacements for hazardous materials technicians. Operations level responders should operate under the guidance of a hazardous materials technician, an allied professional, or standard operating procedures.

safely in a contaminated (or potentially contaminated) atmosphere, responders must stay informed about their working environment. Readings from monitoring and detection devices should always be interpreted in the context of the specific event. Chapter 14, Mission-Specific Competencies: Air Monitoring and Sampling, provides more information on detection and monitoring. Additionally, all emergency responders should be familiar with the policies and procedures of the local jurisdiction to ensure that they employ a consistent approach to the selected control option.

## Control Options

The most challenging aspect of mitigating a hazardous materials emergency is arriving at a solution that can be employed quickly and safely, while minimizing the potential negative effects on people, property, and the environment. If that sounds like a tall order, it is. Handling a hazardous materials incident is a bit like a chess game: One move sets up and (either positively or negatively) influences the next move or series of moves. As mentioned earlier, it is vital to use a risk–based thought process when choosing to employ any control option. Remember—a solid response objective should be well thought out and realistic, taking into account both the positive and negative effects of the actions taken.

Sometimes, no action is the safest course of action. Unfortunate as it may seem, on some occasions the situation is so extreme, or the responders cannot be properly protected, that it may be prudent to create a safe perimeter and let the problem stabilize on its own. In firefighting, certain buildings are recognized as "losers" due to well-advanced or inaccessible fires, inadequate water supply, or untenable conditions. In these cases, an incident commander may choose to pull back, go defensive, and protect exposures (people, animals, the environment, and equipment). A similar mentality should be considered when dealing with some kinds of hazardous materials release scenarios. As an example, a fire in a gasoline tanker may have to burn itself out if not enough foam is available to fight the fire effectively.

Figure 11-1 Sometimes it is necessary to let the problem stabilize on its own.

**Responder Tips**

An accurate size-up must be accomplished prior to taking any action! You must understand the nature of the problem and the ramifications of whatever control option is chosen.

Similarly, when incompatible chemicals are mixed, it may be wise to let the reaction run its course before intervening. Highly volatile flammable liquids may be left to evaporate on their own without taking offensive action to clean them up Figure 11-1. These are but a few examples of situations when no action is a safer way to handle the problem.

As emergency responders approach a hazardous materials incident, they should be aware of natural control points—areas in the terrain or places in a structure where materials might be contained or confined. Natural barriers that might be used include doors to a room, doors to a building, designated areas for secondary containment, and curbed areas of roadways. A number of control measures may be available if responders are thinking creatively and are aware of their surroundings.

### Absorption and Adsorption

Absorption is the process whereby a spongy material (soil or loose absorbents such as vermiculite, clay, or peat moss) or specially designed spill pads are used to soak up a liquid hazardous material Figure 11-2. The contaminated mixture of absorbent material and chemicals are then collected, and all of the materials are disposed of together. Most states have laws and regulations that dictate how to dispose of used absorbent materials.

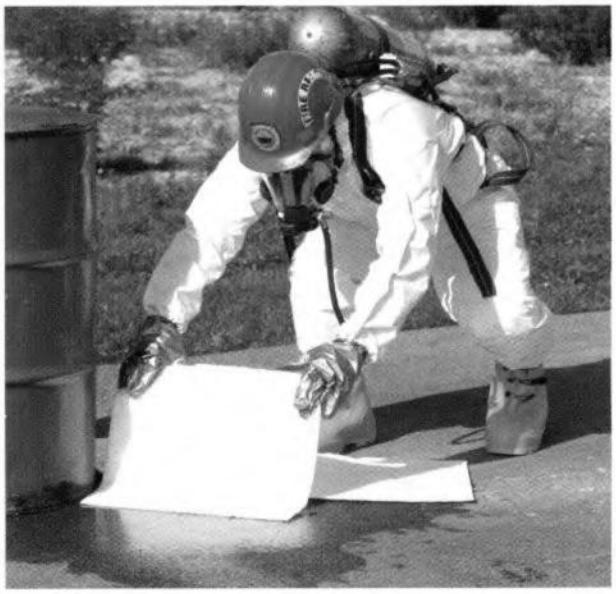


Figure 11-2 Spill pads are often used to soak up a liquid hazardous material.

Absorption minimizes the spread of liquid spills, but is effective only on flat surfaces. Although absorbent materials such as soil and sawdust are inexpensive and readily available, they become hazardous materials themselves once they come in contact with the spilled liquid and, therefore, must be disposed of properly. The process of absorption does not change the chemical properties of the involved substance. It is only a method to collect the substance for subsequent containment.

The technique of absorption may prove challenging for personnel because it requires them to be in close proximity to the spilled material. It also involves the addition of material to a spilled product, which adds volume to the spill. The absorbent material may also react with certain hazardous substances, so it is important to determine whether an absorbent substance is compatible with the hazardous material. Hydrofluoric acid, for example, is not compatible with the silica-based absorbents commonly found in some types of spill booms of a spilled liquid.

In addition, some absorbent materials repel water while still absorbing a spilled liquid that does not mix with water—an effective property under the right circumstances (such as when the goal is to mitigate an oil spill on a body of water). In these situations, spill booms are deployed as floating barriers used to obstruct passage. These booms are typically constructed of an outer mesh covering and filled with a material such as polypropylene or silica. Many different sizes and types of spill booms are on the market today: Again, some will float on water, whereas others are designated for use only on dry land. It is up to your AHJ to decide which types of booms are appropriate for your jurisdiction Figure 11-3.

Figure 11-3 A spill boom can be used to confine a liquid.

**Responder Safety Tips**

It is important to determine whether an absorbent substance is compatible with the hazardous material before it is used.

Another example where the technique of absorption may prove challenging for personnel is an incident involving nitric acid at a concentration higher than 72%. In this situation, the nitric acid becomes such an aggressive oxidizer that using an organic-based absorbent may result in the acid igniting the absorbent material. To reiterate the point made earlier, not all absorbent materials are created equal, and using the wrong one might end up unduly complicating your situation.

The opposite of absorption is adsorption. In adsorption, the contaminant *adheres* to the surface of an added material—such as silica or activated carbon—rather than combining with it (as in absorption). In some cases, the process of adsorption can generate heat—a key point you should consider when use of adsorbent materials is proposed. The concept of adsorption is analogous to the mechanism underlying Velcro: Adsorbents are "sticky" and grab onto whatever substance they are designed to be used for. A common adsorbent material is activated carbon, which is found in the filter cartridges used for air-purifying respirators.

To use absorption/adsorption to manage a hazardous materials incident, follow the steps in Skill Drill 11-1:

1. Collect the basic materials.
   a. Absorbents
   b. Adsorbents
   c. Absorbent pads
   d. Absorbent booms
2. Decide which absorbent/adsorbent is best suited for use with the spilled product and the physical characteristics of the spill (i.e., a spill in a lake, pond, or creek versus on wet or dry ground).
3. Assess the location of the spill and stay clear of any spilled product. (Step 1)
4. Use detection and monitoring devices to determine whether airborne contamination is present. Consult reference sources for the physical and chemical properties of the spilled material.
5. Apply the appropriate material to control the spilled material. (Step 2)
6. Maintain control of the absorbent/adsorbent materials and take appropriate steps for their disposal. (Step 3)

## Damming

Damming is a containment technique that is used when liquid is flowing in a natural channel or depression and its progress can be stopped by blocking the channel. Three kinds of dams are typically used in such circumstances: a complete dam, an overflow dam, or an underflow dam.

A *complete dam* is placed across a small stream or ditch to completely stop the flow of materials through the channel. This

## Skill Drill 11-1

NFPA 472, 6.6.4.1

### Using Absorption/Adsorption to Manage a Hazardous Materials Incident

1 Decide which material is best suited for use with the spilled product. Assess the location of the spill and stay clear of any spilled product.

2 Use detection and monitoring devices as well as reference sources to identify the product. Apply the appropriate material to control the spilled product.

3 Maintain control of the absorbent/adsorbent materials and take appropriate steps for their disposal.

type of dam is used only in areas where the stream or ditch is basically dry and the amount of material that needs to be controlled is relatively small.

For hazardous materials spills in streams or ditches with a continuous flow of water, an overflow or underflow dam must be constructed. An *overflow dam* is used to contain materials heavier than water (specific gravity > 1). It is constructed by building a dam base up to a level that holds back the flow of water Figure 11-4. Polyvinyl chloride (PVC) pipe or hard suction hose is installed at a slight angle to allow the water to flow "over" the released liquid, thereby trapping the heavier material at a low level at the base of the dam.

An *underflow dam* is used to contain materials lighter than water (specific gravity < 1) and is basically constructed in the opposite manner of the overflow dam. The piping on the underflow dam is installed near the bottom of the dam so the waters flow "under" the dam, thereby allowing the materials floating on the water to accumulate at the top of the dam area Figure 11-5. It is

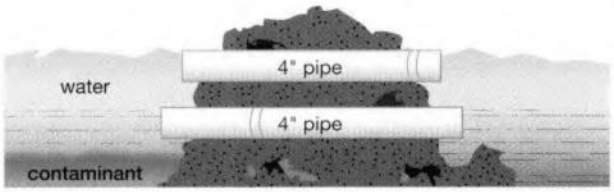



Figure 11-4 An overflow dam is used to contain materials that are heavier than water.

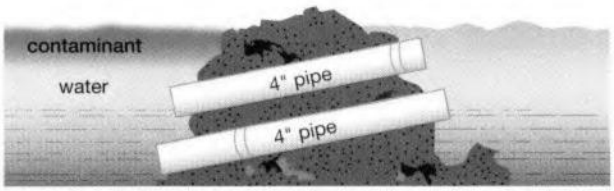


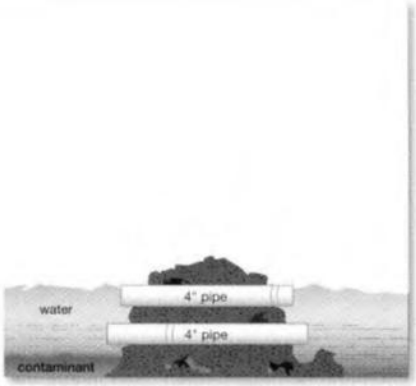

Figure 11-5 An underflow dam is used to contain materials that are lighter than water.

## Skill Drill 11-2

NFPA 472, 6.6.4.1

### Constructing an Overflow Dam

1 Determine the need for and location of an overflow dam. Build a dam with sandbags or other available materials.




2 Install appropriate number of 3- to 4-inch plastic pipes horizontally on top of the dam and add more sandbags on top of the dam. Complete the dam installation and ensure that the piping will allow the proper flow of water without allowing the heavier-than-water material to pass through the pipes.

critical to have sufficient pipes and hoses to allow enough water to flow past the dam without overflowing over the top of the dam.

To construct an overflow dam, follow the steps in **Skill Drill 11-2 ▲**:

1. Based on the spilled material having a specific gravity greater than 1, determine the need and the best location for an overflow dam.
2. Build a dam with sandbags or other available materials. (**Step 1**)
3. Install two to three lengths of 3- to 4-inch plastic pipe horizontally on top of the dam. Add more sandbags on top of the dam if available.
4. Complete the dam installation and ensure that the piping will allow the proper flow of water without allowing the heavier-than-water material to pass through the pipes. (**Step 2**)

To construct an underflow dam, follow the steps in **Skill Drill 11-3 ▶**:

1. Based on the spilled material having a specific gravity less than 1, determine the need and best location for an underflow dam.
2. Build a dam with sandbags or other available materials. (**Step 1**)
3. Install two to three lengths of 3- to 4-inch plastic pipe at a 20- to 30-degree angle on top of the dam. Add more sandbags on top of the dam if available.
4. Complete the dam installation and ensure that the size will allow the proper flow of water underneath the lighter-than-water liquid. (**Step 2**)

## Diking

Diking is the placement of a selected material such as sand, dirt, loose absorbent, or concrete so as to form a barrier that will keep a hazardous material (in liquid form) from entering an unwanted area or to hold the material in a specific location. Before contemplating construction of a dike, you must confirm that the material used to control the hazard will not react adversely with the spilled material.

To construct a dike, follow the steps in **Skill Drill 11-4 ▶**:

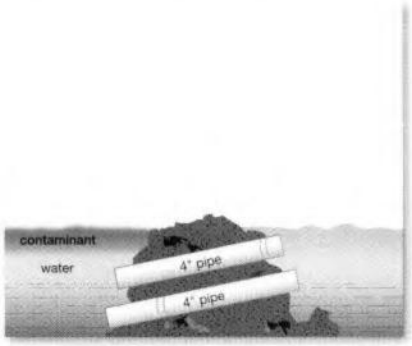
1. Based on the spilled material and the topography conditions, determine the best location for the dike.
2. Dig a depression (if possible) 6 to 8 inches deep.
3. Ensure that plastic will not react adversely with the spilled chemical. Use plastic to line the bottom of the depression, and allow sufficient plastic to cover the dike wall. (**Step 1**)
4. Build a short wall with sandbags or other available materials. (**Step 2**)
5. Install plastic to the top of the dike and secure it with additional sandbags.

## Skill Drill 11-3

NFPA 472, 6.6.4.1

### Constructing an Underflow Dam

1 Determine the need for and location of an underflow dam. Build a dam with sandbags or other available materials.




2 Install appropriate number of 3- to 4-inch plastic pipe at 20- to 30-degree angle on top of the dam and add more sandbags on top of the dam. Complete the dam installation and ensure that the piping will allow the proper flow.

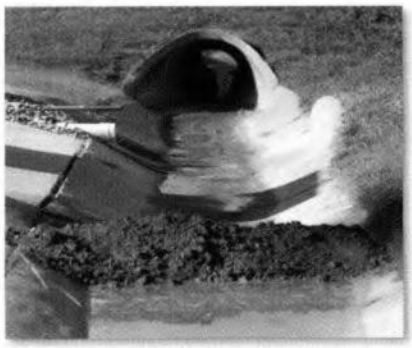
## Skill Drill 11-4

NFPA 472, 6.6.4.1

### Constructing a Dike

1 Determine the best location for the dike. If necessary, dig a depression in the ground 6 to 8 inches deep. Ensure that plastic will not react adversely with the spilled chemical. Use plastic to line the bottom of the depression and allow for sufficient plastic to cover the dike wall.

2 Build a short wall with sandbags or other available materials.



3 Complete the dike installation and ensure that its size will contain the spilled product.

6. Complete the dike installation and ensure that its size will contain the spilled product. It may be necessary to construct a series of dikes if there is a concern about the amount of product being released. A wise incident commander will consider backing up the original structure to ensure that the product will be controlled effectively. (Step 3)

## Dilution

Dilution is the addition of water or another substance to weaken the strength or concentration of a hazardous material (typically a corrosive). Dilution can be used only when the identity and properties of the hazardous material are known with certainty. One concern with dilution is that water applied to dilute a hazardous material may simply increase the total volume; if the volume increases too much, it may overwhelm the containment measures implemented by responders. For example, if 1 gallon of water were added to 3 gallons of spilled hydrochloric acid (pH = 3), the result of this action would be the creation of 4 gallons of hydrochloric acid (pH = 3); it takes a *tremendous* amount of water to effectively dilute such a low-pH acid. Dilution should be used with extreme caution and only on the advice of those knowledgeable about the nature of the chemicals involved in the incident.

To use dilution to manage a hazardous materials incident, follow the steps in Skill Drill 11-5:

1. Based on the spilled material's characteristics and the size of the spill, determine the viability of a dilution operation.
2. Obtain guidance from a hazardous materials technician, technical specialist such as a chemist, or other qualified allied professional.
3. Ensure that the water used will not overflow and affect other product-control activities.
4. Add small amounts of water from a distance to dilute the product. If applicable, check the pH periodically during this operation.
5. Contact the hazardous materials technician (or other qualified professional) if any additional issues arise. (Step 1)

## Diversion

Diversion techniques in general are intended to redirect the flow of a liquid away from an endangered area where it will have less impact. In many cases, however, responders do not need to build elaborate dikes to divert the flow of a spilled liquid. Instead, existing barriers—such as curbs or the curvature of the roadway—may be effective ways to divert liquids away from storm drains or other unwanted destinations. Additionally, dirt berms, spill booms, and plastic tarps filled with sand, dirt, or clay may provide a rapidly employed diversion mechanism. These diversion methods are not as "permanent" as a dike, and they can be constructed fairly quickly. Remember—the intent of diversion is to protect sensitive environmental areas or any other areas that would be unsuitable for the spilled liquid.

To employ a diversion technique to manage a spilled liquid, follow the steps in Skill Drill 11-6:

1. Based on the spilled material and the topography conditions, determine the best location for the diversion.
2. Use sandbags or other materials to divert the product flow to a more desirable location. This location may not be perfect, but may be more advantageous to the overall control efforts.
3. Stay clear of the product flow.
4. Monitor the diversion channel to ensure the integrity of the system. (Step 1)

## Skill Drill 11-5

NFPA 472, 6.6.4.1

### Using Dilution to Manage a Hazardous Materials Incident

1

Determine the viability of a dilution operation. Obtain guidance from a hazardous materials technician, specialist, or professional. Ensure that the water used will not overflow and affect other product-control activities. Add small amounts of water from a distance to dilute the product. Contact the hazardous materials technician, specialist, or other qualified professional if any additional issues arise.

## Skill Drill 11-6

NFPA 472, 6.6.4.1

### Constructing a Diversion

1 Determine the best location for the diversion. Use sandbags or other materials to divert the product flow to an area with fewer hazards. Stay clear of the product flow. Monitor the diversion channel to ensure the integrity of the system.

## Retention

Retention is the process of creating a defined area to hold hazardous materials. For instance, it may involve digging a depression in the ground and allowing material to pool in the depression. The material is then held there until a clean-up contractor can recover it. In some cases, some sort of diversion technique may be required to guide the spilled liquid into the retention basin. As an example, a city's public works department or an independent contractor might use a backhoe to create a retention area for runoff at a safe downhill distance from the release.

To use retention, follow the steps in Skill Drill 11-7 ▸:

1. Based on the spilled material and the topography conditions, determine the best location for the retention system.
2. Dig a deep depression (by hand or with heavy equipment such as a tractor or backhoe) to serve as a retention basin.
3. Use plastic to line the bottom of the depression (if time permits and the spilled liquid is compatible with plastic).
4. Use sandbags or other materials to hold the plastic in place.
5. Stay clear of the product flow.
6. Monitor the retention system to ensure its integrity. (Step 1)

## Remote Valve Shut-off

A protective action that should always be considered—especially with transportation emergencies or incidents at fixed facilities—is the identification and isolation of remote valve shut-off. Many chemical processes, and many piped systems that carry chemicals, provide a way to remotely shut down a system or isolate a leaking fitting or valve. This action may prove to be a much safer way to mitigate the problem Figure 11-6 ▸.

Fixed ammonia systems provide a good example of the effectiveness of using remote valve shut-offs. In the event of a large-scale ammonia release, most current systems have a main dump valve that will immediately redirect anhydrous ammonia into a water deluge system or diffuser. These systems are designed to knock down the vapors and collect the resulting liquid in a designated holding system.

Many types of cargo tanks have emergency remote shut-off valves. MC-306/DOT-406 cargo tanks, for example, carry flammable and combustible liquids and Class B poisons. These single-shell aluminum tanks may hold as much as 9200 gallons of product at atmospheric pressure. The tanks have an oval/elliptical cross-section and overturn protection that serves to protect the top-mounted fittings and valves in the event of a

### Responder Safety Tips

Participating in product control operations may require a great deal of physical energy and mental concentration. Remember to take rehabilitation breaks throughout the incident to minimize the effects of heat stress and fatigue. Refer to NFPA 473, *Standard for Competencies for EMS Personnel Responding to Hazardous Materials/WMD Incidents*, for more information on heat stress.

## Skill Drill 11-7

NFPA 472, 6.6.4.1

### Using Retention to Manage a Hazardous Materials Incident

1 Determine the best location for the retention system. Dig a depression in the ground to serve as a retention area. Use plastic to line the bottom of the depression. Use sandbags or other materials to hold the plastic in place. Stay clear of the product flow. Monitor the retention system to ensure its integrity.

Figure 11-6 When available, consider using remote shut-off valves to mitigate the problem.

rollover. In the event of fire, a fusible link is designed to melt at a predetermined temperature (typically around 250°F); its collapse causes the closure of the internal product discharge valve. A baffle system within the cargo tank compartment reduces the surge of the liquid contents. Remote shut-off valves are often located near the front of the cab (adjacent to the driver's door) or at the rear of the cargo tank Figure 11-7.

MC-307/DOT-407 cargo tanks carry chemicals that are transported at low pressure, such as flammable and combustible liquids as well as mild corrosives and poisons. These vehicles may carry as much as 7000 gallons of product and are outfitted with many of the safety features similar to those found on the MC-306/DOT-406 cargo tanks Figure 11-8.

MC-331 cargo tanks carry compressed liquefied gases such as anhydrous ammonia, propane, butane, and liquefied petroleum gas (LPG). The tanks, which are not insulated, have rounded ends, baffles, and a circular cross-section. MC-331 cargo tanks have a carrying capacity between 2500 and 11,500 gallons. These types of cargo tanks have remote shut-off valves located at both ends of the tank, internal shut-off valves, a rotary gauge depicting product pressure, and top-mounted vents Figure 11-9.

## Vapor Dispersion and Suppression

When a hazardous material produces a vapor that collects in an area or increases in concentration, vapor dispersion or suppression measures may be required.

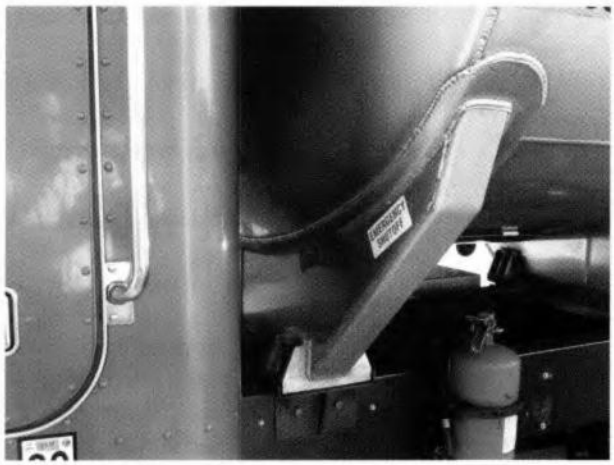


Figure 11-7 The remote shut-off valve is typically found near the front of the cab, adjacent to the driver's door, or at the rear of an MC-306/DOT-406 cargo tank.

Figure 11-9 The MC-331 cargo tank has remote shut-off valves at both ends of the tank, internal shut-off valves, a rotary gauge depicting product pressure, and two top-mounted vents.

Vapor dispersion is the process of lowering the concentration of vapors by spreading the vapors out. Vapors can be dispersed with hose streams set on fog patterns, large displacement fans (being mindful of the fan itself becoming a source of ignition), or other types of mechanical ventilation found in fixed hazardous materials handling systems. Before dispersing vapors, the consequences of this action should be considered. If the vapors are highly flammable, an attempt to disperse them may ignite the vapors. The dispersed vapors can also contaminate areas outside the hot zone. Vapor dispersion with fans or a fog stream should be attempted only after the hazardous material is safely identified and in weather conditions that will promote the diversion of vapors away from any populated areas.

Figure 11-8 The remote shut-off valve is typically found near the front of the cab, adjacent to the driver's door, or at the rear of an MC-307/DOT-407 cargo tank.

Conditions must be constantly monitored during the entire operation.

Vapor suppression is the process of controlling fumes or vapors that are given off by certain materials, particularly flammable liquids, in an attempt to prevent their ignition. It is accomplished by covering the hazardous material with foam or some other material, or by reducing the temperature of the material. For example, gasoline gives off vapors that present a danger because they are flammable. To control these vapors, a blanket of firefighting or vapor-suppressing foam is layered on the surface of the liquid.

Not all vapor-suppressing foams are appropriate for all types of applications. Much like the concept of choosing the right PPE to protect you from a hazardous substance, responders must choose a type of foam that is designed to work in certain situations. For example, Class A foam is typically used to fight fires involving ordinary combustible materials such as wood and paper. In most situations involving hazardous materials or weapons of mass destruction (WMD) agents, Class A foam is *not* the most appropriate type of foam to use. Class B foam, by contrast, is used to fight fires and suppress vapors involving flammable and combustible liquids such as gasoline and diesel fuel. This type of foam seals the surface of a spilled liquid and prevents the vapors from escaping, thereby reducing the danger of vapor ignition. If the vapors are burning, a gently applied foam blanket will also spread out over the surface of the liquid and work to smother the fire.

Responders should be aware of the nature of the materials that are released and the way in which particular foam concentrates behave when they are applied. Take the time to become familiar with the types of foam concentrates that may be used by your agency.

Reducing the temperature of some hazardous materials will also suppress vapor formation. Unfortunately, there is no easy way to accomplish this goal except in cases of small spills.

Employ this control measure only after consulting with a hazardous materials technician level responder or another subject-matter expert in the field.

To use vapor dispersion to manage a hazardous materials release, follow the steps in Skill Drill 11-8:

1. Based on the characteristics of the released material, the size of the release, and the topography, determine the viability of a dispersion operation.
2. Use the appropriate monitoring instrument, such as a combustible gas indicator, photo-ionization detector, or multi-gas meter, to determine the boundaries of a safe work area.
3. Ensure that ignition sources in the area have been removed or controlled. (Step 1)
4. Apply a water spray (from firefighting hose lines) from a distance to disperse vapors.
5. Monitor the environment until the vapors have adequately dispersed. (Step 2)

To perform vapor suppression actions using foam, follow the steps in Skill Drill 11-9:

1. Based on the characteristics of the released material, the size of the leak, and the topography, determine the viability of a vapor suppression operation.
2. Use the appropriate instrument to determine the boundaries of a safe work area.
3. Ensure that ignition sources in the area have been removed or safely controlled.
4. Apply appropriate type of foam from a safe distance to suppress vapors.
5. Monitor the environment until the vapors have been adequately suppressed. (Step 1)

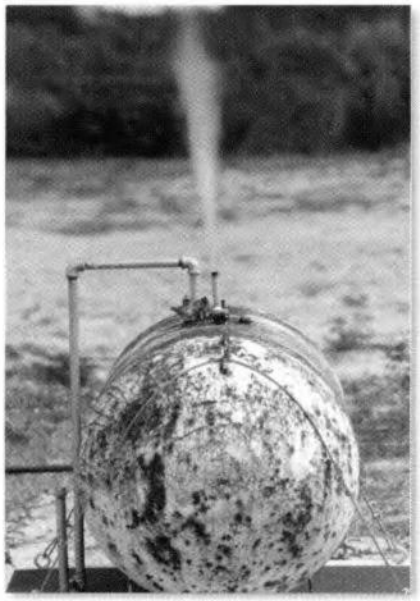
Always remember that as foam is applied, more volume will be added to the spill. All of the foams listed below suppress the ignition of flammable vapors and may be used to extinguish fires in flammable or combustible liquids:

- Aqueous film-forming foam (AFFF) can be used at a 1%, 3%, or 6% concentration. This type of foam is designed to form a blanket over spilled flammable liquids to suppress vapors or on actively burning pools of flammable liquids. Foam blankets are designed to prevent a

## Skill Drill 11-8

NFPA 472, 6.6.4.1

### Using Vapor Dispersion to Manage a Hazardous Materials Incident



1 Determine the viability of a dispersion operation. Use the appropriate monitoring instrument to determine the boundaries of a safe work area. Ensure that ignition sources in the area have been removed or controlled.

2 Apply water from a distance to disperse vapors. Monitor the environment until the vapors have been adequately dispersed.

## Skill Drill 11-9

NFPA 472, 6.6.4.1

### Using Vapor Suppression to Manage a Hazardous Materials Incident

1 Determine the viability of a vapor suppression operation. Use the appropriate instrument to determine the boundaries of a safe work area. Ensure that ignition sources in the area have been removed or controlled. Apply foam from a safe distance to suppress vapors. Monitor the environment until the vapors have been adequately suppressed.

fire from reigniting once extinguished. Most AFFF foam concentrates are biodegradable. AFFF is usually applied by way of in-line foam eductors, foam sprinkler systems, and portable or fixed proportioning systems.

- Alcohol-resistant concentrates have properties similar to AFFF, except that they are formulated so that alcohols such as methyl alcohol and isopropyl alcohol and other polar solvents will not dissolve the foam. (Regular protein foams cannot be used on these types of products.)
- Fluoroprotein foam contains protein products mixed with synthetic fluorinated surfactants. These foams can be used on fires or spills involving gasoline, oil, or similar products. Fluoroprotein foams rapidly spread over the fuel, ensuring fire knockdown and vapor suppression. Fluoroprotein foams, like many of the synthetic foam concentrates and other types of special-purpose foams, are resistant to polar solvents such as alcohols, ketones, and ethers.
- Protein foam concentrates are made from hydrolyzed proteins (animal by-products), along with stabilizers and preservatives. These types of foams are very stable and possess good expansion properties. They are quite durable and resistant to reignition when used on Class B fires or spills involving nonpolar substances such as gasoline, toluene, oil, and kerosene.
- High-expansion foam is utilized when large volumes of foam are required for spills or fires in warehouses, tank farms, and hazardous waste facilities. It is not uncommon to have a yield of more than 1000 gallons of finished foam from every gallon of foam concentrate used. The expansion is accomplished by pumping large volumes of air through a small screen coated with a foam solution. Because of the large amount of air in the foam, high-expansion foam is referred to as "dry" foam. By excluding oxygen from the fire environment, this agent smothers the fire, leaving very little water residue.

There are several ways to apply foam. Foam concentrates (other than high-expansion foam) should be gently applied or bounced off another adjacent object so that they flow down across the liquid and do not directly upset the burning surface. Foam can also be applied in a rain-down method by directing the stream into the air over the material and letting the foam gently fall onto the surface of the liquid, as rain would. To apply the rain-down method, follow the steps in Skill Drill 11-10 ▸:

1. Open the nozzle and test to ensure that foam is being produced.
2. Move within a safe range of the product and open the nozzle.
3. Direct the stream of foam into the air so that the foam gently falls onto the pool of the product.
4. Allow the foam to flow across the top of the pool of product until it is completely covered. (Step 1)

The rain-down method is less effective when the fire is creating an intense thermal column. When the heat from the thermal column is high, the water content of the foam will turn

## Skill Drill 11-10

NFPA 472, 6.6.4.1

### Performing the Rain-Down Method of Applying Foam

1

Open the nozzle to ensure that foam is being produced. Move within a safe range of the product and open the nozzle. Direct the stream of foam into the air so that the foam gently falls onto the pool of the product. Allow the foam to flow across the top of the pool of the product until it is completely covered.

to steam before it comes in contact with the liquid surface. Foam can also be applied via the roll-in method by bouncing the stream directly into the front of the spill area and allowing it to gently push forward into the pool rather than directly "splashing" it in. To apply foam using the roll-in method, follow the steps in Skill Drill 11-11 ▸:

1. Open the nozzle and test to ensure that foam is being produced.
2. Move within a safe range of the product and open the nozzle.
3. Direct the stream of foam onto the ground just in front of the pool of product.
4. Allow the foam to roll across the top of the pool of product until it is completely covered. (Step 1)

The bounce-off method is used in situations where the fire fighter can use an object to deflect the foam stream and let it flow down onto the burning surface. For example, this method could be used to apply foam to an open-top storage tank or a rolled-over transport vehicle. The foam should be swept back and forth against the object while the foam flows down and spreads back across its surface. As with all foam application methods, it is important to let the foam blanket flow gently on the surface of the flammable liquid to form a blanket. To perform the bounce-off method of applying foam, follow the steps in Skill Drill 11-12 ▸:

1. Open the nozzle and test to ensure that foam is being produced. (Step 1)
2. Move within a safe range of the product and open the nozzle.
3. Direct the stream of foam onto a solid structure such as a wall or metal tank so that the foam is directed off the object and onto the pool of product.
4. Allow the foam to flow across the top of the pool of product until it is completely covered.
5. Be aware that the foam may need to be banked off of several areas of the solid object so as to extinguish the burning product. (Step 2)

## Recovery

The recovery phase of a hazardous materials incident occurs when the imminent danger to people, property, and the environment has passed or is controlled, and clean-up begins. During the recovery phase, local, state, and federal agencies may become involved in cleaning up the site, determining the responsible party, and implementing cost-recovery methods. The recovery phase in large-scale incidents can go on for days, weeks, or even months and may require large amounts of resources and equipment Figure 11-10 ▸.

## Skill Drill 11-11

NFPA 472, 6.6.4.1

### Performing the Roll-In Method of Applying Foam

1 Open the nozzle and test to ensure that foam is being produced. Move within a safe range of the product and open the nozzle. Direct the stream of foam onto the ground just in front of the pool of product. Allow the foam to roll across the top of the pool of product until it is completely covered.

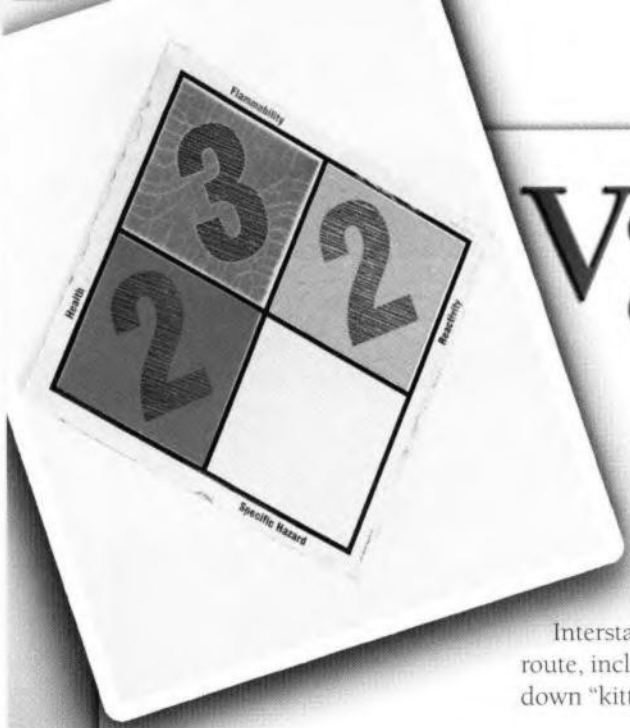
## Skill Drill 11-12

NFPA 472, 6.6.4.1

### Performing the Bounce-Off Method of Applying Foam

1 Open the nozzle and test to ensure that foam is being produced.

2 Move within a safe range of the product and open the nozzle. Direct the stream of foam onto a solid structure such as a wall or metal tank so that the foam is directed off the object and onto the pool of product. Allow the foam to flow across the top of the pool of product until it is completely covered. Be aware that the foam may need to be banked off of several areas of the solid object so as to extinguish the burning product.




# Voices *of* Experience

There are times where all the aspects of what you have learned just come together. This happened to me on one very cold February night.

I had been an officer for a couple of years at the time of this incident, and was feeling comfortable in my knowledge base. We were called to a report of a multiple-vehicle crash, including one semi, at a particular mile marker on Interstate 25. The semi was reported to be leaking diesel fuel. We assembled our plan en route, including scene safety, security, patients, patching the hole in the tank, and throwing down "kitty litter" and pads to clean up what had spilled.

*"Worse than that was the fact that the semi wasn't leaking fuel from a saddle tank as we predicted; it was on its side and this particular MC-307/DOT-407 was leaking diesel fuel from the top of the tanker trailer."*

We didn't realize that this particular mile marker included a bridge over a lake. The semi was on its side and the MC-307/DOT-407 was leaking diesel fuel from the top of the tanker trailer. The fuel hadn't begun dripping off the side of the bridge, but we knew we had less than ten minutes before it did.

While two fire fighters checked the scene and assessed patients, one fire fighter grabbed what we had of "kitty litter" and pads to create a small diversion dam and a small sponge area to give us a little time. We knew it wouldn't hold, and we needed more material to make it last. Help was quickly called for the department's complete stock of "kitty litter," public works personnel with lots of sand (which I was told would be at least 45 minutes in arriving), and the regional hazardous materials team.

Using the "kitty litter" we had, we built a long diversion barrier to allow the diesel fuel to slowly flow down the length of the bridge toward its end, away from its edge. We also used the natural traffic ruts in the interstate to help us with this task. Where the flow reached the end of the bridge, we had several fire fighters working with picks and axes to break up the ground. These fire fighters created a dam to retain the flow in place with the dirt they were able to break up.

Once the public works department arrived, we used the equipment and truckloads of dirt they brought to reinforce both our diversion barrier and the dam. This completely contained the spill until the clean-up and offloading crews arrived, along with representatives of the regional hazardous materials team. Upon their arrival, we turned the scene over to them and went back in service (another crew remained on scene to help with offloading the tanker).

On the way back, it occurred to us that the information we learned in hazardous materials classes really does work, and that multiple techniques and scenarios can easily apply to just one incident (recognition, diking, absorption, diversion, containment, damming, recovery phase, and retention). By taking the appropriate steps, remaining flexible, and using all the knowledge we had gained, we had prevented this incident from becoming a serious environmental nightmare.

Be safe out there.

Philip Oakes
Laramie County Fire District #4
Cheyenne, Wyoming

In some situations, there is a clear transition between the emergency phase and the clean-up phase. The decision to declare a change from the emergency phase to the recovery phase is typically made by the incident commander. For example, a distinct hand-off between on-scene public safety responders and private-sector commercial clean-up companies would fit this description. It is not uncommon for public-sector responders to hand off the clean-up operations, but remain on scene to ensure that the operation is carried out properly. As long as public safety personnel and responders remain on the scene, they should maintain their vigilance for safety to ensure that no new hazards are created or injuries incurred during the recovery phase.

At other times, the initial responders perform both the emergency response and the clean-up. For example, responders often handle in their entirety small gasoline spills resulting from auto accidents or spills at gas stations.

### Responder Tips

The ultimate goal of the recovery phase is to return the property or site of the incident to its preincident condition, and to return the facility or mode of transportation to the responsible party.

### Responder Tips

After performing any product control procedure, follow your local procedures for technical decontamination.

**Figure 11-10** The recovery phase involves clean-up, determination of the responsible party, and implementation of cost recovery.

The transition from emergency to clean-up should be carried out in a manner consistent with your agency's standard operating procedures and the guidelines determined by your AHJ. The recovery phase also includes completion of the records necessary for documenting the incident.

# Wrap-Up

## Chief Concepts

- When considering a control option, a variety of factors must be evaluated, such as the maximum quantity of material that can be released and the likely duration of the incident if no intervention is made.
- Sometimes the situation is so extreme, or the proposed action is so risky, that it may be prudent to create a safe perimeter and let the problem stabilize on its own.
- Control techniques or options generally aim to contain, redirect, or lower the concentration of the hazardous material involved and/or to prevent the ignition of flammable liquids or gases.
- Responders can employ a variety of product-control options, such as absorption, diversion, damming, diking, or isolating a leak with remote shut-off valves.
- Special foams can help both in vapor suppression actions and in extinguishment of fires associated with flammable liquid releases.
- Responders should be aware of the locations of emergency shut-off valves at fixed facilities and on the various types of cargo tanks typically found in their response area.
- The recovery phase may last for days or months and aims to return the exposure area to its original condition and return the facility or mode of transportation to the responsible party.

## Hot Terms

Absorption The process of applying a material that will soak up and hold a hazardous material in a sponge-like manner for collection and subsequent disposal.

Adsorption The process in which a contaminant adheres to the surface of an added material—such as silica or activated carbon—rather than combining with it (as in absorption).

Alcohol-resistant concentrate A foam concentrate with properties similar to those of an aqueous film-forming foam, except that the concentrate is formulated so that alcohols and other polar solvents will not break down the foam.

Aqueous film-forming foam (AFFF) A water-based extinguishing agent used on Class B fires that forms a foam layer over the liquid and stops the production of flammable vapors.

Confinement The process of keeping a hazardous material within the immediate area of the release.

Containment Actions relating to stopping a leak from a hazardous materials container, such as patching, plugging, or righting the container.

Damming The product-control process used when liquid is flowing in a natural channel or depression, and its progress can be stopped by constructing a barrier to block the flow.

Diking The placement of materials to form a barrier that will keep a hazardous material in liquid form from entering an area or that will hold the material in an area.

Dilution The process of adding a substance—usually water—in an attempt to weaken the concentration of another substance.

Diversion The process of redirecting spilled or leaking material to an area where it will have less impact.

Exposures The process by which people, animals, the environment, and equipment are subjected to or come into contact with a hazardous material.

Fluoroprotein foam A blended organic and synthetic foam that is made from animal by-products and synthetic surfactants.

High-expansion foam A foam created by pumping large volumes of air through a small screen coated with a foam solution. Some high-expansion foams have expansion ratios ranging from 200:1 to approximately 1000:1.

Protein foam A foam that is made from organic materials. It is effective on non-alcohol-type fuels such as gasoline and diesel fuel.

Recovery phase The stage of a hazardous materials incident after imminent danger has passed, when clean-up and the return to normalcy have begun.

Remote valve shut-off A type of valve that may be found at fixed facilities utilizing chemical processes or piped systems that carry chemicals. These remote valves provide a way to remotely shut down a system or isolate a leaking fitting or valve. Remote shut-off valves are also found on many types of cargo containers.

Retention The process of purposefully collecting hazardous materials in a defined area.

Vapor dispersion The process of lowering the concentration of vapors by spreading them out, typically with a water fog from a hose line.

Vapor suppression The process of controlling vapors given off by hazardous materials, thereby preventing vapor ignition, by covering the product with foam or other material or by reducing the temperature of the material.

# Responder *in Action*

Your engine company has arrived on the scene of an MC-306 flammable liquid cargo tanker parked on the side of the interstate. Prior to your arrival, the dispatch center advised you that the tanker is carrying gasoline. Upon arrival, you notice the beginnings of a stream of released liquid flowing from the underside of the tank, away from your location. The driver approaches you and confirms the product to be gasoline, and states that he has no idea why the leak is occurring. The air temperature is approximately 90°F and the winds are calm. You are considering the options available to control the released liquid.

1. Where would be the most likely places to find the remote shut-off valves on this type of cargo tanker?
   - **A.** Underneath the truck, near the front and rear wheels
   - **B.** Adjacent to the driver's door or at the rear of the cargo tank
   - **C.** Inside the cab next to the MSDS or under the passenger seat
   - **D.** On top of the cargo tank; one on the front of the tank and the other at the rear
2. Assuming that the leak has been stopped and approximately 500 gallons of liquid is now retained in a catch basin, which type of foam might be applied effectively to this type of product (gasoline) to suppress the vapors?
   - **A.** High-expansion foam
   - **B.** Foam eduction solution
   - **C.** Surfactant foam concentrate
   - **D.** AFFF foam
3. You notice the AFFF foam blanket appears to be breaking down too quickly. Which of the following statements best describes a likely cause?
   - **A.** The pavement temperature is too hot; the foam is breaking down due to heat.
   - **B.** The AFFF foam is incompatible with the spilled liquid; you should consider switching to an alcohol-resistant type foam.
   - **C.** The pool of spilled liquid is too deep; foam works only on shallow pools of liquid.
   - **D.** You should change nothing; keep applying the same foam.
4. Imagine that the leak worsens, to the point that the flowing liquid has now reached an adjacent 15-foot-wide drainage canal with water flowing in it. It is decided to build a dam to capture the flowing gasoline. Which of the following types of dams would be appropriate given the physical properties of gasoline?
   - **A.** A diversion dam
   - **B.** An underflow dam
   - **C.** An overflow dam
   - **D.** A retention dam

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