Hazardous Material Management and Hazard Communication

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Hazardous Material Spills and Response

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LEARNING OBJECTIVES

- Identify the three federal agencies that regulate some aspect of hazardous material spills and releases and understand the basic roles of each.
- Gain an awareness of the various types of federal, public, private, and community sources of information and other assets.
- Know what types and sizes of spills or releases must be reported and to whom they must be reported.
- Gain a basic understanding of terms and concepts that relate to hazardous materials.
- Be able to perform a hazard assessment, and then develop and implement a site-specific emergency response plan.
- Understand federal hazardous materials training requirements.
- Learn the terms used in planning for and conducting responses to hazardous material spills or releases.

THE THREE PRIMARY agencies at the federal level that promulgate and enforce laws and regulations relating to spills and releases of hazardous materials are the U.S. Department of Transportation (DOT), the Environmental Protection Agency (EPA), and the Occupational Safety and Health Administration (OSHA). Because these regulations tend to intertwine and overlap, it is important to gain a general understanding of the role of each agency. The information that follows consists of significantly condensed overviews of the regulations. Complete information can be found in the appropriate section of the Code of Federal Regulations (CFR), published by the Government Printing Office.

Individual states have the right to promulgate and enforce standards that are stricter than the federal rules, except in the case of DOT regulations. According to 49 CFR 171.1(f), states may not impose provisions that are substantially different from any hazardous materials transportation law, regulation, or directive issued by the Secretary of Homeland Security.

In general, OSHA regulations apply to the safety and health of workers involved in spill clean up; EPA regulations apply to protection of the environment during and after the spill (including treatment and disposal of waste products and residues); and DOT regulations apply to the transportation of hazardous materials and waste resulting from the spill. As previously stated, agency regulations tend to overlap at times. For example, parts of DOT regulations are incorporated into EPA regulations and vice versa, and OSHA promulgated and enforces the *Hazardous Waste Operations and Emergency Response* (HAZWOPER) standard under a mandate from EPA. The resolution of any spill or release is likely to be governed by more than one federal agency as well as state and local agencies.

Department of Transportation

The mission of DOT as stated on its Web site at www.dot.gov/mission.htm is to "Serve the United States by ensuring a fast, safe, efficient, accessible and convenient transportation system that meets our vital national interests and enhances the quality of life of the American people, today and into the future."

DOT is composed of thirteen departments, nine of which are major modal, multimodal, and/or intermodal agencies. Of these agencies, the Pipeline and Hazardous Materials Safety Administration (PHMSA) provides many transportation-related safety and research services. Within PHMSA the Office of Hazardous Materials Safety is responsible for most of the regulations concerning the packaging and transportation of hazardous materials and hazardous waste in commerce.

DOT divides hazardous materials into hazard classes and divisions. A hazard class is a single-digit number—3 or 8, for example. Some hazard classes are further divided into divisions. Gases, for example, may be flammable, nonflammable, or toxic (poisonous, or pose an inhalation hazard). The general hazard class for all gases is 2. Specific hazards within the class are listed in specific divisions: flammable gases are in division 2.1; nonflammable gases are in division 2.2; and toxic, poisonous, or inhalation gases are in division 2.3.

Gases and liquids that pose an acute inhalation hazard are assigned to a Hazard Zone. In 49 CFR 171.8, "Definitions and Abbreviations," DOT defines "Hazard Zone" as one of four levels of hazard (Hazard Zones A through D) assigned to gases, as specified in 49 CFR 173.116(a), and one of two levels of hazards (Hazard Zones A and B) assigned to liquids that are poisonous by inhalation, outlined in 49 CFR 173.133(a). As specified in 49 CFR 173.133(a), the hazard zone is based on the LC_{50} value for acute inhalation toxicity of gases and vapors.

Federal Hazardous Materials Transportation Law

The hazardous materials transported in the United States are regulated by the U.S. Department of Transportation. The primary purposes of these regulations are to provide regulatory and enforcement authority to DOT to protect against the inherent risks during the transportation of hazardous materials in commerce. The Hazardous Materials Regulations (HMR) can be found in section 49 of the Code of Federal Regulations, Parts 171–178, which is generally written as 49 CFR 171–178.

The Hazardous Materials Transportation–Uniform Safety Act (HMT–USA) was enacted by Congress in 1990 to clarify conflicting state, local, and federal regulations. Additionally, this statute provides for the regulation of the transportation of radioactive materials and provides criteria for the issuance of federal permits to motor carriers of hazardous materials.

Transportation Security

Hazardous material shipments are very vulnerable when in transit. Without adequate security, tens of thousands of pounds of hazardous materials are accessible to unscrupulous individuals and groups. Some potential security risks include the theft or hijacking of vehicles carrying hazardous materials, tampering with valves on trucks or valves at tank farms, tampering with railroad equipment and cars, and tampering with other bulk transportation equipment. Additionally, forged shipping papers and fraudulent shipments of hazardous materials can put these materials in the wrong hands.

Written transportation security plans are required for organizations that offer or transport hazardous materials in commerce. The Department of Transportation's Pipeline and Hazardous Materials Safety Administration's *Hazardous Materials: Risk-Based Adjustment of Transportation Security Plan Requirements*, effective October 1, 2010, expands the requirement for shippers to prepare security plans. The current requirements for security plans include all placarded shipments as well as a "large bulk quantity" of hazardous materials. A *large bulk quantity* is any amount greater than 3000 kilograms (6614 pounds) of solids or 3000 liters (792 gallons) for liquids or gases in a single packaging, such as a cargo-tank motor vehicle, portable tank, tank car, or other bulk container.

DOT requires transportation security awareness training for all hazmat employees and in-depth security training for employees of an employer that is required to have a transportation security plan. General hazardous material training requirements are listed at 49 CFR 172.704. Detailed security training requirements are listed at 49 CFR 172.704 (a)(4) and (5) and 172.800.

DOT also requires that shippers of hazardous materials provide a 24-hour emergency telephone number on shipping papers (49 CFR 172.201(d)), so that in the event of an accident involving hazardous materials, 24-hour help is available. A helpful resource available from DOT is the *Emergency Response Guidebook*, which is designed to aid responders to hazardous material releases.

Environmental Protection Agency

The mission of the EPA, as shown at www.epa.gov, is to protect human health and the environment. EPA is a vast organization with many agencies that directly or indirectly oversee the management of hazardous material spills and releases. Of the federal agencies, EPA was the first to formalize emergency planning requirements. It is the controlling agency for most spills on land. Several branches of the EPA have separate spill prevention and reporting requirements for those facilities that manufacture or use certain chemicals. Some of the major laws and regulations are discussed below.

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)

CERCLA, commonly known as Superfund, was signed into law by Congress in 1980. This law imposed a tax on the petroleum and chemical industries that went into a trust fund for cleaning up abandoned or uncontrolled hazardous waste sites. CERCLA also gave the federal government authority to respond directly to releases or threatened releases of hazardous substances that may endanger human health or the environment and to provide for legal and financial liability of those responsible for releases of hazardous waste at these sites. In 1986, CERCLA was amended by the Superfund Amendments and Reauthorization Act (SARA). The most significant short-term effect of SARA was to increase the size of the clean-up trust fund to $8.5 billion.

EPA developed a list of chemicals, which, when released, could cause serious harm to human health and the environment. Facilities having any of these acutely toxic substances on site at any one time, above certain threshold levels, are subject to the emergency planning provisions of SARA Title III. SARA Title III is composed of four parts:

- Sections 301–303: These sections provide for the establishment of state emergency response commissions (SERCs) and local emergency planning committees (LEPCs).
- Section 304: This section states that facilities must notify the proper agencies if there is a release of a hazardous substance that exceeds the reportable quantity for that substance. The lists of chemicals are found at 40 CFR 355 and 40 CFR 302.4.
- Sections 311–312 (Community Right-to-Know) Reporting Requirements: This section requires that material safety data sheets (MSDSs) be submitted to the local emergency planning committee, state emergency response commission, and the local fire department. These reports are called Tier I and Tier II reports. Facilities do not have to submit reports if they have less than 500 pounds or the threshold planning quantity (whichever is less) of extremely hazardous substances—or have less than 10,000 pounds of hazardous chemicals, as defined by OSHA's *Hazard Communication Standard*.
- Section 313: This section provides for annual reporting requirements for companies that manufacture, process, or use a listed material in quantities greater than specific threshold quantities. Approximately 175 of the Section 313 toxic chemicals have been designated "Section 313 Water Priority Chemicals." Regulated facilities must meet the minimum pollution prevention plan requirements and must also comply with special provisions for areas where water priority chemicals are stored, processed, or otherwise handled. These provisions include standards for appropriate containment, drainage control, and diversionary structures.

The Resource Conservation and Recovery Act (RCRA)

RCRA was passed by Congress in 1976. Its primary goals are to ensure that all wastes are managed in a way that protects human health and the environment, to promote waste reduction and minimization, and to encourage recycling and recovery of energy and natural resources. RCRA regulations provide for cradle-to-grave management of hazardous wastes, imposing regulations on those who generate, transport, treat, store, dispose of, and recycle hazardous waste.

Clean Air Act (CAA)

The Clean Air Act of 1990, along with other EPA regulations, set minimum pollution guidelines. All states have developed and implemented EPA-approved state implementation plans (SIPs), which detail how each state administers CAA regulations. It is the CAA that requires "air" permits for those who discharge certain pollutants into the air.

Clean Water Act (CWA)

The CWA was originally called the Federal Water Pollution Control Act Amendments of 1972. After it was amended in 1977, it was more commonly called the Clean Water Act. The CWA sets standards for surface water quality and industrial wastewater discharges. The Spill Prevention, Control, and Countermeasures (SPCC) regulation (40 CFR 112) was created in 1973 under authority of the Clean Water Act. This regulation established spill prevention procedures, methods, and equipment requirements for nontransportation-related facilities with aboveground oil storage capacity greater than 1320 gallons (or greater than 660 gallons aboveground in a single tank) or underground oil storage capacity greater than 42,000 gallons. Facilities regulated by SPCC include those at which an accidental discharge could reasonably be expected to reach navigable waters. These accidents might include facilities where, in the event of a spill, rainwater could wash the spill into a stream or enter the groundwater.

The CWA also established the National Pollutant Discharge Elimination System (NPDES) permit (40 CFR 122), a nationwide program that regulates the sources of discharged pollutants into waters. Under the authority of the Clean Water Act, EPA requires facilities to develop and implement stormwater pollution prevention plans and conduct site inspections. Facilities subject to SARA Title III are also subject to additional NPDES requirements. Many individual states oversee implementation and administration of this program in their state.

Oil Pollution Act (OPA)

OPA contains provisions for facilities and vessels that have the potential to discharge oil. The significance of OPA is that it establishes civil, criminal, and financial liability to the responsible party of facilities and vessels from which oil is discharged (or which pose a substantial threat of oil discharge). Responsible parties must demonstrate evidence of financial responsibility and are liable for most costs resulting from a spill or discharge of oil. OPA also establishes requirements for contingency and emergency response plans.

Occupational Safety and Health Administration

OSHA's Web site states that its primary goal is to protect worker safety and health (www.osha.gov/oshinfo/mission.htm). To this end, OSHA has promulgated regulations concerning numerous specific occupational safety and health hazards. In the event that a particular hazard is not directly covered by a standard, the Occupational Safety and Health Act contains a General Duty Clause that requires all American employers to provide a workplace free of recognized hazards that cause, or are likely to cause, serious harm or death to employees. The two most relevant OSHA standards pertaining to spills and releases of hazardous materials are the *Hazard Communication Standard* (HCS) and *Hazardous Waste Operations and Emergency Response* (HAZWOPER).

The Hazard Communication Standard (HCS)

The primary goal of the HCS (29 CFR 1910.1200) is to reduce the number of chemically related occupational illnesses and injuries. Employers who use hazardous chemicals must have on hand a written program that provides information to employees who may be exposed to hazardous chemicals under normal conditions or in a foreseeable emergency. The program must include a determination of the hazards present in the workplace and discuss measures that employees must take to protect themselves against those hazards, thus reducing exposure to hazardous chemicals. The HCS also requires employers to maintain copies of material safety data sheets (MSDSs) on each chemical they use.

When a good hazard communication program has been developed and implemented in the workplace, workers will be able to protect themselves in the event of a small spill. They will know how to find, read, and interpret pertinent information on MSDSs. They will have been trained on labeling/hazard recognition and will know what kind of personal protective equipment they need to protect themselves from the chemical hazards presented by the spill.

As of early 2010, OSHA is proposing to change the requirements of the HCS to comply with the recommendations of the *Global Harmonization System* (GHS) proposed by the United Nations. The proposed changes include changing the name and format of MSDS, additional hazard categories and rankings, and new labels (pictograms). Additional information may be found on OSHA's Web site at www.osha.gov/dsg/hazcom/ghs.html.

Hazardous Waste Operations and Emergency Response

As the name implies, the HAZWOPER standard (29 CFR 1910.120) covers two major categories of workers: those whose primary function is to perform hazardous waste operations and those who perform emergency response. Emergency response includes work relating to actual or threatened releases of hazardous substances regardless of the location of the hazard. Hazardous waste operations include the following:

- hazardous substance clean-up operations required by a governmental body at uncontrolled hazardous waste sites, including initial hazard investigations at government-identified sites
- clean ups at RCRA sites
- voluntary clean up of uncontrolled hazardous waste sites
- hazardous waste operations that are conducted at RCRA treatment, storage, and disposal (TSD) facilities
- emergency responses without regard to location

An *uncontrolled hazardous waste site* is an area on either public or private land where the presence of hazardous substances creates a threat to people or the environment. To be considered an uncontrolled hazardous waste site, the site must be designated as such by a federal, state, or local government agency.

As used by OSHA, the term *emergency response* alludes to response efforts by employees or others (such as the local fire department) from outside the immediate release area to an emergency that results, or could result, in an uncontrolled release of a hazardous substance. Generally speaking, if the spill or other release is incidental and can be managed by employees in the immediate area or by maintenance personnel, the response effort is not covered under this standard, but it would still be covered under the HCS and perhaps under other standards, depending on the circumstances.

There are exceptions to the standards and regulations, so one must always read the full standard or regulation carefully to determine which parts apply to one's particular situation. For example, under certain conditions, conditionally exempt small-quantity generators do not have to comply with parts of the HAZWOPER standard.

The HAZWOPER standard specifies that an employer should have an emergency response plan in effect that would include pre-emergency planning; required training, personnel roles, all lines of authority, and communication; emergency recognition and prevention; designated safe distances and places of refuge; site security and control; evacuation routes and procedures; any decontamination procedures that are not covered by the employer's comprehensive site safety and health plan; provisions for emergency medical treatment and first aid; emergency alerting and response procedures; lists of personal protective and emergency equipment; and a critique of response and follow up.

In practical terms, the HCS mandates that employers have an MSDS for all hazardous materials used in the workplace, and that all employees must be trained on the nature of the hazards and how to protect themselves from those hazards. The HAZWOPER standard addresses pre-emergency planning, emergency equipment and procedures, and training for personnel. If all employers develop and implement the plans, programs, and training required by these two standards, spills and other releases—whether small or large—will likely be managed in a safe and efficient manner.

Federal Assets and Sources of Information

Two essential requirements for any hazardous material spill response planner are: (1) technical details and properties of the materials for which the plan is being developed and (2) a sense of how the operation should be conducted—an operational definition of *good*. There are several federal government Web sites that provide information to meet both of these requirements.

These Web sites are useful for new planners who are looking for basic information as well as for personnel revising or updating existing plans. The list below is not intended to be exhaustive, but rather to provide entry onto the information superhighway.

Organization: Agency for Toxic Substances and Disease Registry

Web site: www.atsdr.cdc.gov
Typical information:

–Hazardous substances

- ToxFAQs: These are chemical-specific fact sheets that provide answers to frequently asked questions about exposures to hazardous substances found around hazardous waste sites and the effects of exposure on human health.

–Information Sources

- The HazDat database includes the hazardous substances release and health effects database.

–Emergency Response

- This provides information on training recommendations and technical databases for hazardous substances.

–Publications

- These are lists of publications available for downloading or in printed format.

Organization: Centers for Disease Control and Prevention

Web site: www.cdc.gov
Typical information:

–Health and Safety Topics

- These topics cover emergency preparedness and response, including preparation and planning information and chemical emergency information.
- The focus is often on chemical emergencies, including an MSDS database from the Department of Energy.

Organization: Department of Justice

Web site: www.justnet.org
Typical information:

The basic concepts in numerous publications are based on the needs of law enforcement and corrections, but the documents provide concise and useful information for planners and emergency responders.

–Publications

- *Draft NIJ CBRN Protective Ensembles for Law Enforcement*
- *Comparative Evaluation of Protective Gloves for Law Enforcement and Correction Applications*
- *Guidance on Emergency Responder Personal Protective Equipment (PPE) for Response to CBRN Terrorism Incidents*
- *Guidance for the Selection of Chemical and Biological Decontamination Equipment for Emergency First Responders*

Organization: Department of Transportation

Web site: www.phmsa.dot.gov
Typical Information:

Emergency Response Guidebook (ERG). This emergency responders' guide is intended to assist in quickly identifying the specific or generic characterization of a hazardous material in an incident and to assist in protecting emergency responders during the initial response phases of an incident.

Organization: Federal Emergency Management Agency

Web site: www.fema.gov and www.usfa.fema.gov (U.S. Fire Administration)

Typical information:

–Typical information covered is incident management, including information on creating response management systems and coordinating plans with local and federal agencies.

Organization: National Institute of Occupational Safety and Health (NIOSH)

Web site: www.cdc.gov/niosh

Typical information:

NIOSH Pocket Guide to Chemical Hazards (NPG). This is a concise source of general industrial hygiene information for workers, employers, and occupational health professionals on 677 chemicals or substances commonly found in the work environment.

Organization: Occupational Safety and Health Administration (U.S. Department of Labor)

Web site: www.osha.gov/dep/etools

Typical information:

–Information covered is the Health and Safety Program, electronic format (e-HASP). An important message is that a safe response must be a planned response. This site shows than an excellent tool either for drafting new health and safety plans or for reviewing existing plans is the electronic health and safety plan. The following is a brief outline of the online plan. See the *E-Hasp$_2$ Software User's Manual* for complete information and details on each element.

- Organizational Structure: Documents how the authority, responsibility, and duties are divided among the various agencies and members of a response team.
- Job Hazard Analysis (JHA): This is a technique used to help identify, then reduce or eliminate, hazards. JHAs focus on the relationship between the worker, the task, the tools, and the work environment.
- Site Control: This plan shows how to define boundaries of contaminated zones and work areas. It also explains how to identify safe work practices, methods of routine and emergency communication, methods of controlling entry into contaminated areas, and methods of controlling the migration of site contaminants.
- Training Program: The training program identifies the jobs and tasks that require training, and how much and what type of training is needed for each. It describes how changing site-specific conditions or information will be communicated to employees and other site workers. It also tells where and how training documentation will be maintained.
- Medical Surveillance Requirements: This aspect describes various requirements and techniques, such as physical examinations, biological testing, the collection of workplace exposure data, and other needs that are mandated by various OSHA standards. A good resource for medical surveillance information is the Web site www.osha.gov/SLTC/medicalsurveillance/index.html.
- Personal Protective Equipment (PPE): What is described here is how PPE is selected, fit, used, stored, and maintained. This site tells how personnel will be trained for proper use and how one can ensure that workers are physically capable of using PPE under routine and extreme conditions, such as during emergencies or periods of extreme heat or cold.
- Exposure Monitoring: This part discusses how and when monitoring for hazardous

contaminants will be conducted. Included is a discussion of the monitoring instruments that will be used and how they will be calibrated and maintained. If an accredited analytical laboratory will be used, one can find how to describe sampling procedures and sample handling procedures.

- Thermal Stress: This describes measures to be taken to protect site workers from the effects of heat and cold stressors.
- Spill Containment Program: What is provided here is detailed information about the actions that will be taken in the event of a spill or a leak. Included is information about the equipment that is to be used to control and contain the released material; where tools and equipment are located; the personnel who are to respond; how and when to obtain off-site assistance; and other site-specific information.
- Decontamination Program: Described here are procedures to decontaminate personnel and equipment. Also explained is how disposable and reusable equipment will be managed and how to ensure decontamination is effective.
- Emergency Response Plan: This is a written plan that identifies the actions employees will take in the event of a chemical release, fire, accident, injury, or other type of emergency that may occur at the site.
- Standard Operating Procedures: Here, one can learn how to develop procedures to ensure safe, consistent, work practices that will minimize employee contact with hazardous substances and provide compliance with applicable standards and regulations.
- Confined Space Programs: If confined spaces are a potential site hazard, refer to 29 CFR 1910.146, Permit-Required Confined Spaces, to determine whether the circumstances necessitate the development and implementation of a written, confined-space-entry program.
- Hot Work: If welding, cutting, or other hot work is to be performed at the site, develop safety and operating procedures; list worker roles and responsibilities, and describe the location(s) where the hot work is to be conducted.
- Lockout/Tagout: If applicable, and based on site conditions, one can develop specific procedures that can be used to protect workers from the unexpected start up or energization of machinery and equipment and from the release of hazardous energy during equipment maintenance or other activities where energy could be suddenly released.

Organization: U.S. Coast Guard

Web site: www.uscg.mil/vrp

Typical information:

–Shipboard Oil Pollution Emergency Plans (SOPEP) and Shipboard Marine Pollution Emergency Plans (SMPEP).

- The Oil Pollution Act of 1990 (OPA-90) and the international treaty, MARPOL 73/78, require owners/operators of certain vessels to prepare a Vessel Response Plan (VRP) and/or Shipboard Oil Pollution Emergency Plans (SOPEP) approved by the U.S. Coast Guard. In addition, for certain vessels carrying noxious liquid substances, MARPOL 73/78 requires owner/operators to prepare and submit Shipboard Marine Pollution Emergency Plans (SMPEP), effective January 1, 2003. Access to information and key elements contained in those plans is available from the above Web site.
- These plans provide lists of the types of information and formats that good plans, even those not involving marine spills, should include.

Public and Community Assets

Many public and private community assets exist, both for providing assistance in emergency spill response situations and for providing help or guidance to facilities that want to ensure that they are doing everything possible to prevent spills and respond adequately in the event of a spill or release. The following assets are examples of the types of services that could be available in your area.

Public Service Agencies

In many cases, emergency responders to large spills or transportation spills will include some type of public service agency, such as the local police, fire, and/or emergency medical service (EMS) department. Local police departments generally do not participate directly in incident management, but may assist by securing the scene, managing traffic, routing emergency equipment, or notifying other local or state emergency response agencies. Approximately 65 percent of all fire departments provide EMS services and often have hazardous material teams whose members are trained and equipped to manage many types of emergency spills and releases (BLS, 2007).

Communication and preplanning with the local fire department are often required by state or local law, usually for facilities that have larger quantities of hazardous materials. Facilities of any size that use or store materials that pose unusual hazards during a fire should coordinate with the local fire department to discuss those hazards. For example, firefighters need to know if a material is water-reactive *before* they use water to try to extinguish it. Telling them after the ensuing explosion is useless. Likewise, local doctors, hospitals, and other medical facilities should be contacted prior to an emergency and made aware of the types of injuries and illnesses they can expect to see in the event of a spill or release so they are able to prepare adequately.

Industry-Related Assets

Responsible Care® (www.responsiblecare.org) is a voluntary initiative developed by the chemical industry. The Responsible Care initiative is a comprehensive environmental, health, and safety management system composed of ten key elements through which participating companies work together to improve their environmental, safety, health, and security performance.

Many chemical companies also participate in the Community Awareness and Emergency Response (CAER) program (described at www.caer-mp.org). Each CAER member-company has developed and implemented an emergency response program that enables it to respond quickly and effectively to emergencies at its facility. CAER members also have community outreach programs to address questions and concerns about any safety, health, and environmental issues concerning their product or process.

The International Organization for Standardization (ISO) (www.iso.org) developed a set of standards—a complete management system—that helps facilities adopt a proactive approach to managing environmental issues. By developing and implementing programs and best practices found in ISO 14000 and the Occupational Health and Safety Assessment Series (OSHAS) 18000, any type of facility or organization—large or small, public or private—can improve its safety and environmental programs. Sound environmental management results in cost savings such as reduced raw materials and energy consumption and less hazardous and nonhazardous waste generation and disposal. Sound safety and environmental management will reduce the likelihood of spills and releases and result in more efficient management of incidents if and when they occur.

Community Assets

Local emergency planning committees (LEPCs) are typically composed of emergency responders (both public and private), local industry, emergency management agencies, and the community. LEPCs take an active role in community emergency planning and are responsible for developing a community emergency plan for response to chemical emergencies. They often provide services such as the review of a facility's contingency plans, public education, industry outreach, and development and implementation of emergency drills and exercises. For more information about LEPCs, or to find out what services, if any, your LEPC offers, visit www.fema.gov/hazard/hazmat/hz_cres.shtm or search for your state's Web-site listing.

Federal Notification and Reporting Requirements

The National Response Center (NRC)

The NRC is the sole federal point of contact for reporting regulated oil and chemical spills. The NRC maintains a 24-hour-per-day, 7-days-per-week, 365-days-per-year Operations Center, where all information is received via a toll-free number entered directly into an online database system, and electronically disseminated as part of the National Response System. Information such as the material involved, mode of transportation, injuries, damage, and fatalities will be disseminated to select federal agencies within 15 minutes of receipt. When any of the following incidents occur, the NRC should immediately be contacted by the responsible party via the toll-free number. Anyone who sees or discovers an oil spill or release of chemicals, even if he or she is not the responsible party, should immediately contact the NRC with whatever information is available.

- Oil spills in or along U.S. navigable waters: The definition of "navigable waters" found in 40 CFR 112.2 is rather broad and lengthy. Generally speaking, however, the term includes *all* waters that are currently used, were used in the past, or may be susceptible to use in interstate or foreign commerce, including territorial seas, rivers, ponds, streams, wetlands, wetlands adjacent to waters, lakes, impoundments, prairie potholes, wet meadows, and other areas in which the use, degradation, or destruction of which could affect interstate or foreign commerce.
- CERCLA requires that all releases of hazardous substances exceeding reportable quantities be reported by the responsible party to the NRC. Title 40 CFR Part 302 promulgates reportable quantities and reporting criteria. All the Extremely Hazardous Substances (EHS) that overlap with the CERCLA-listed chemicals table (40 CFR Part 302.4) should also be reported.
- Certain transportation accidents (see below under Department of Transportation).
- Others, including gas and liquid pipeline releases and discharges from a hazardous waste treatment or storage facility. Abandoned dump or waste sites should be reported by anyone having knowledge of such a site.

Department of Transportation

To comply with 49 CFR 171.15, incidents of the following types that occur during the loading, unloading, or storage of hazardous materials in commerce must be reported to the NRC by telephone by the person who has physical possession of the hazardous material(s) as soon as possible, but no later than 12 hours after the incident:

1. Incidents where, as a direct result of a hazardous material,
   - a person is killed
   - a person receives an injury requiring admittance to a hospital
   - the general public is evacuated for an hour or longer
   - a major transportation artery or facility is closed or shut down for at least an hour or the operational flight pattern or routine of an aircraft is altered
2. Incidents where breakage, spillage, or suspected radioactive contamination occurs involving a radioactive material
3. Incidents where breakage, spillage, or suspected contamination occurs involving an infectious substance other than a diagnostic specimen or regulated medical waste
4. Incidents where a release of a marine pollutant occurs in a quantity exceeding 119 gallons (450 L) for a liquid or 882 pounds (400 kg) for a solid
5. Incidents where a situation exists of such a nature that, in the judgment of the person in possession of the hazardous material, it should be reported to the National Response Center, even if it does not meet the above criteria

For incidents involving infectious substances, the report may instead be forwarded to the Centers for Disease Control and Prevention in Atlanta, Georgia, at (800)232-0124. Each report must include the following information:

- name of the reporter
- name and address of the person represented by the reporter
- telephone number where the reporter can be contacted
- date, time, and location of the incident
- extent of injury, if any
- if available, the proper shipping name, hazard class or division, and quantity of hazardous material involved
- type of incident and nature of hazardous material involvement and whether a continuing danger to life exists at the scene

Within 30 days of the incident, the person who makes the report must also file a written report on DOT Form F 5800.1.

DOT also requires that a written report be made when there has been an unintentional release of hazardous materials from a package (including a tank), or when any quantity of hazardous waste has been unintentionally discharged during transportation. Reports of hazardous waste discharges must include a copy of the hazardous waste manifest and other information, such as an estimate of the quantity of the waste removed from the scene, the name and address of the facility to which it was taken, and the manner of disposition of any removed waste. There are some exceptions to the reporting requirements, so refer to the full text of 49 CFR 171.16 for details.

Environmental Protection Agency

Under 40 CFR 302.6, EPA requires persons in charge of facilities (including transport vehicles, vessels, and aircraft) to report any release of a hazardous substance in a quantity equal to or greater than its reportable quantity, as soon as that person has knowledge of the release, to the National Response Center at (800)424-8802 or (202) 267-2675. The term *reportable quantity* (RQ) means the quantity, as set forth in 40 CFR 302, the release of which requires notification pursuant to the regulations contained in 40 CFR 302.

State Requirements

Federal "States' Rights" Legislation

Some environmental laws are national in applicability. Deviations from these federal laws are not allowed. For example, transportation laws regulating hazardous materials may not be altered. All states must follow DOT regulations and standards because only Congress, as authorized by the U.S. Constitution, may regulate commerce between states. Bulk and nonbulk packages of hazardous materials must meet the manufacturing and quality assurance standards set by DOT at 49 CFR 178. Labels and placards must meet federal specifications set by DOT at 49 CFR 172. Some laws, however, allow states to add to, but not delete from, federal standards. For example, the document that must accompany shipments of hazardous waste—the Uniform Hazardous Waste Manifest (40 CFR 262)—was created by the Resource Conservation and Recovery Act (RCRA). All states must use the Uniform Hazardous Waste Manifest, but space is allotted on the form for state-specific waste codes. Lists of state-specific variations and additions are available at EPA regional offices or state environmental compliance agencies.

At the federal level, generators of hazardous waste may not store hazardous waste more than 90 days with a storage permit. Generators, at the federal level, may, however, use satellite accumulation areas, at or near the point of waste generation and under the control of the operator of the process generating the waste, to accumulate up to 55 gallons of waste without a time limit. Some states, however, do not allow satellite sites. In those jurisdictions, generators must ship all waste off site within 90 days or obtain a storage permit. This interplay of federal regulations and state-specific requirements tends to confound spill response plans and procedures because states and regional authorities within states may set specific standards that differ from federal requirements. Many state and federal regulations contain provisions for resolving conflicts between regulatory bodies. In the case of contradictory requirements, the more restrictive regulation generally applies. If in doubt, ask one or both of the agencies involved for a written, legal interpretation of the regulation(s) in question.

Personnel Licensing and Registration

Some states have established licensing and registration requirements for companies and individuals assessing the severity of a specific situation, conducting spill response operations, or determining the need for additional remediation efforts after the majority of the spilled material has been recovered or removed. For example, California's Environmental Protection Agency Department of Toxic Substances Control has published a *Preliminary Endangerment Assessment Guidance Manual*. Only individuals qualified as and recognized as a registered environmental assessor (REA) may complete a preliminary endangerment assessment (PEA) to determine if a spill or release site is *clean* or needs additional remediation. The Connecticut Department of Environmental Protection has established Remediation Standard Regulations. Connecticut also qualifies, tests, and recognizes environmental professionals. When organizations with only a single facility plan a spill response to include determining whether the spill or release has been remediated, contacting a single state environmental regulatory organization will be sufficient. For national organizations with facilities in numerous locations, spill response plans must include state and regional contacts, registration, and licensing requirements for specific operations and individuals. Check with your state's environmental agency to determine whether licensing or registration is required.

Notifications and Response Actions

Virtually all jurisdictions within the United States require notification of a spill or release based on the specific material(s) involved and the amount and location of the spill. The agency to which the notification is sent may be the local fire department, a state agency, or a statewide notification center. Generally, the emphasis is on responding quickly and safely to the spill or release. A spill response planner must be aware of the type(s) of notification(s) required, the organization(s) to which the notification should be sent, and the format of the notification(s), and should include this information in the spill response plan. Nationwide commercial organizations must include this information for specific facilities. Planners who write specific response plans must contact the local fire department or state environmental agency to verify reporting and notification requirements.

POST-CLEAN-UP RESPONSE REQUIREMENTS

After the initial spill response actions have been completed, there is generally a requirement to assess, examine, or test the spill site to determine whether any harmful residual levels of the spilled materials or contaminants remain. As noted earlier, various states and regional authorities may have product-specific standards in certain areas of the United States. These authorities must be consulted, and their approval, if required, obtained before any long-term remediation work is initiated. In most jurisdictions, the sampling and analytical procedures in *Test Methods for Evaluating Solid Waste* (Physical/Chemical Methods) EPA Publication SW-846 (www.epa.gov/epaoswer/hazwaste/test/main.htm) must be followed. Because sampling involves specific procedures, methods, and sometimes health or safety hazards, only personnel with the appropriate knowledge should be permitted to obtain samples. Many environmental service companies and laboratories offer sampling services. Additionally, several good references are available. One is EPA publication EPA530-D-02-002, *RCRA Waste Sampling Draft Technical Guidance— Planning, Implementation, and Assessment* (August 2002). Another good resource is *ASTM Standards on Environmental Sampling*, now in its third edition (2006), which is published by ASTM International (www.astm.org).

For any post-clean-up issues concerning building safety or reoccupancy, consult local building codes or contact the local fire department for guidance.

Soil Decontamination

Soil decontamination is important for its own sake as well as to prevent cross-media contamination. Spill residues entrained in soil may volatilize and become airborne clouds of gases and vapors. On the other hand, contaminated soil may dry and be displaced by the wind, creating clouds of hazardous particulate matter. Soils highly contaminated by releases or spills may be removed during the emergency phase of the response, making decontamination a moot point. More likely, low levels of contamination will exist on the horizontal and vertical peripheries of the spill. Those are the soils that must be decontaminated. As in all phases of spill response, knowing the nature of the contaminant may indicate the type of decontamination that will be most efficient. Some heavy metals, such as arsenic, tend to be relatively soluble and migrate through the soil. Thus a 100-square-foot area of arsenic-contaminated soil after a spill may become a 1000-square-foot decontamination problem if not addressed quickly. Dense nonaqueous-phase liquids (DNAPLs) will migrate through soil, sink through the groundwater in the saturated soil zones, and cause both soil and groundwater decontamination problems.

A spill of elemental or white phosphorus results in extensive soil contamination. Because white phosphorus is a spontaneously combustible material, repeatedly tilling the contaminated area over a period of weeks forces the phosphorus to the surface, where it simply burns itself out. In a case like this, cross-media contamination (air contaminated by burning phosphorus) is determined to be less of a human and environmental health and safety concern than allowing the phosphorus to remain in place.

Groundwater

Groundwater decontamination is nearly always difficult. Especially in the case of sole-source aquifers, contamination must be reduced to extremely low levels. This reduction may be accomplished by pumping the contaminated groundwater to surface treatment units or, in some situations, by biological or chemical processes, using bacteria to degrade the contamination in place, or using chemicals to either oxidize or reduce the contamination. Depending on soil conditions, it may be necessary to inject the decontaminating chemicals directly into the groundwater. Or, it may be more efficient to build porous barriers in the soil, allowing contaminated groundwater to flow through the decontaminating barrier or reactive zone. The contaminants will be oxidized or reduced as they are carried by the water through these subsurface structures.

Building and Equipment

There are some specific clean-up standards in EPA regulations. The clean-up standard for polychlorinated biphenyls (PCBs), for example, is published at 40 CFR 761 and includes acceptable residual levels of PCBs. Experience often has shown, however, that there is no specific standard. Cleaning to background levels or method detection limits in SW-846 may be extremely expensive without providing any benefit to human health or the environment. OSHA standards may be used to provide some guidance for decontamination in industrial or commercial facilities. Recognizing human health and safety are the primary concerns; there will probably be requirements to clean processing equipment so that manufactured goods meet specifications and are not contaminated with spill residues.

Applied Scientific and Engineering Principles in Environmental Management

Chemical and Physical Properties of Hazardous Materials

The physical state of the material being dealt with will often determine the seriousness of a spill or release. Solids tend not to disperse as rapidly in the environment as liquids or vapors. Powdered solids, however, may become airborne quickly and create contaminated environments, both locally affecting spill response workers and, downwind from the release site, creating hazardous areas for people, the environment, and continuing operations.

When *water-insoluble liquids* that are lighter than water are spilled on water, they tend to spread over wide areas because these materials are dispersed by wind, current, or tidal flow. Water-insoluble liquids that are heavier than water tend to sink directly to the bottom and may form localized, concentrated, highly contaminated areas. The extent of the contamination depends to a large extent on bottom conditions and current characteristics.

Water-soluble liquids, when spilled on water, may be impossible to remove from the environment completely because the entire water column, from top to bottom, is contaminated. Water-soluble liquids, when spilled on soil, tend either to permeate the soil or to dissolve in precipitation and sink into the soil until groundwater is encountered. They tend to contaminate large areas.

Water-insoluble liquids spilled on soil tend to spread more slowly than water-soluble materials. These contaminated areas will be relatively small.

Water-soluble solids, when spilled on water, may be impossible to remove. As with water-soluble liquids, they contaminate the entire water column. Water-insoluble solids, when spilled on water, will either float or sink. Water-insoluble solids that are lighter than water tend to spread over wide areas because these materials are dispersed by wind, current, or tidal flow. Water-insoluble solids that are heavier than water tend to sink directly to the bottom and may form localized, concentrated, highly contaminated areas.

Spilled solid materials tend not to penetrate soils very deeply. However, water-soluble solid materials that are spilled on soil may dissolve in precipitation and act as a liquid, contaminating large areas.

The *boiling point* (BP) of a liquid is the temperature at which a liquid turns to vapor. Materials with a boiling point below ambient temperatures will evaporate rapidly, forming vapor clouds that may endanger both responders and people, operations, and the environment downwind from the spill or release (Bowling Green State University 2008).

The *lower explosive limit* (LEL) and the *upper explosive limit* (UEL) establish the range of flammability. The LEL is the minimum concentration of a material in air that will support combustion, given an ignition source. A synonym for LEL is LFL (*lower flammable limit*). Below the LEL, the material-to-air mixture is too lean to burn. The UEL is the highest concentration of a material in air that will support combustion, given an ignition source. Above the UEL, the material-to-air mixture is too rich to burn.

The instrument that measures the concentration of flammable vapors in air is called a combustible gas indicator (CGI). It is generally calibrated to either methane or pentane and displays contamination as a percentage of the LEL (%LEL). The highest level that OSHA has determined as safe for entry into confined or poorly ventilated spaces is 10% LEL. CGI readings are generally displayed as large numbers—percentages in air or tens of thousands of parts per million. Permissible exposure limits (PELs) and threshold limit values (TLVs) are generally small numbers—often only tens or hundreds of parts per million. It is critical that, after an atmosphere is tested for flammability with a CGI, it is tested for low levels of hazardous vapors with direct-reading organic vapor instruments to determine proper personal protective equipment. Because a CGI measures flammability, not toxicity, a toxic atmosphere may exist, but it might not be detected.

The *flash point* (Fl. P.) of a material is the temperature at which sufficient vapors are generated to support combustion, given an ignition source. Materials with flash points well below ambient temperatures pose extreme risk of fire and explosions to response workers. An extremely low flash point often determines both what and how emergency responders conduct operations, at least until the source of the flammable vapors is controlled.

The *ionization potential* (IP) of a material is the amount of energy, measured in electron volts (eV), that is required to form an ion. An instrument commonly used during spill responses to measure vapors in air is a photo ionization detector, or PID. A PID can detect many solvents, but only if the ionization lamp in the instrument produces more electron volts than are required by the molecule(s) of concern to form ions. Thus a PID with a low energy bulb may give very low readings when in high concentrations of vapor(s) with high ionization potential(s). PIDs are commonly calibrated to isobutylene in the low parts-per-million range. One should always refer to the manufacturer's instructions when interpreting instrument readings because a specific material may cause an instrument response that is significantly different from the actual levels of contamination. PIDs can be used to determine the need for, and type of, respiratory protection.

Specific gravity (Sp. Gr.) is the weight of a material relative to water (water being defined as having a specific gravity of 1). Materials with a Sp. Gr. of less than 1 will float on water and may spread significantly from the original release site. Such materials released onto soil tend to permeate or diffuse into the soil to the top of the water table, then float on underground water. This forms large pools of contaminated water that often require extensive and lengthy remediation efforts. Materials with a Sp. Gr. greater than 1 will sink in water. If such a material is released onto surface water, clean up or removal may be impossible without herculean efforts. Materials with a Sp. Gr. greater than 1 released onto soil may permeate into the ground, sinking through groundwater until a confining layer (a layer of geologic material such as clay, rock, or compressed silt that has little or no permeability) is encountered.

Vapor density (VD), sometimes expressed as the *relative vapor density* (Rel. VD), is a ratio of the density of the released gas(es) or vapor(s) compared to air, with the density of air equaling 1. Materials with a vapor density less than 1 will tend to rise and disperse. Materials with a density greater than 1 will tend to form pockets in low or poorly ventilated areas. Thus storm drains near a spill or release may contain hazardous concentrations of spilled, high-density gases and vapors. These drains may form dispersion pathways, allowing the spilled materials to contaminate large areas. Vapor density should always be used as a very general measure of the ability of a vapor to disperse. For example, mercury has a VD of 13.5, but air currents caused by personnel walking near a spill site will cause mercury vapors to rise and disperse in air (Bowling Green State University 2008).

Vapor pressure (VP) is the pressure, generally measured in millimeters of mercury (mm Hg) in equilibrium with the liquid or solid phase of the same material. VP will affect both on-site and off-site operations. Low vapor-pressure materials may produce relatively small contaminated areas with relatively low inhalation risks and small, if any, downwind hazard areas. On the other hand, high vapor-pressure materials may create large areas of high contamination, requiring the on-site use of respiratory protection equipment for long periods. In addition, high vapor-pressure materials may create large, long-lasting hazard areas downwind of the spill site.

Viscosity is the resistance of a liquid to flow or move. Highly viscous materials cling to surfaces—including personal protective equipment worn by response workers—the soil surface, and any equipment or structure in the spill or release site. High-viscosity fluids are typically difficult to decontaminate. Low-viscosity fluids may tend to disperse rapidly on soil or surface waters.

Miscibility is the ability of two liquids to form a uniform blend. For example, the DOT *Emergency Response Guidebook* (ERG) uses miscibility in lieu of solubility. The term may be used as a synonym for *solubility*. The water solubility, or miscibility, of a spilled material affects how the material will spread from the release site. A water-miscible material that is allowed to contact water will probably never be recovered. Surface waters will spread the material, creating huge areas with huge volumes of contaminated water. Controlling access to the contaminated water until natural forces dilute the spill to acceptable levels will probably be the remediation technique used. Groundwater aquifers contaminated with a water-soluble material may be abandoned, thus requiring new water supplies. It may not be possible, in some cases, to remediate the groundwater.

Water-immiscible materials may be either lighter than water (having a specific gravity less than 1) or heavier than water (having a specific gravity greater than 1). Water-immiscible, low-specific-gravity liquids will float on surface water until they degrade or meet a physical barrier. A gasoline spill on a river is an example of a water-immiscible material. If this type of material is allowed to soak into the ground and contaminate the aquifer, extensive decontamination will be required.

Water-immiscible, high-specific-gravity materials will sink to the bottom of any body of surface water. Removing these materials may be physically and financially impossible. Contaminated sediments and sludges in industrial harbors are examples of these materials. Water-immiscible, high-specific-gravity liquids are so difficult to remove from groundwater that they have been given a specific name: *DNAPLs, or dense nonaqueous-phase liquids*. Again, time is critical. Keeping these materials contained at or near the spill site can prevent major pollution events. Responding slowly, allowing these materials to seep into the soil, can create conditions that require decades to restore or remediate.

Nature of the Spilled Material–Measures of Toxicity

Common measures of toxicity that affect an exposed population are called the lethal dose (LD) for a liquid or solid and the lethal concentration (LC) for a gas or vapor. The dose that kills 50 percent of the organisms in a test for skin contact or ingestion is called the LD_{50}. The concentration (in air) of a gas or vapor that kills 50 percent of the organisms in a test of respiratory exposure is shown as the LC_{50}. The proposed Global Harmonization System (GHS) expands the measure of toxicity to include target organ systemic toxicity (TOST) for either a single exposure or repeated exposures (UNECE 2005).

The *permissible exposure limit* (PEL) is the exposure ceiling set by OSHA that most workers can be exposed to based on 8-hour workdays and 40-hour work weeks. A PEL is measured as a *time-weighted average* (TWA). A TWA is the mathematical average value of a chemical exposure over the course of an 8-hour work shift. Longer exposure times—more than 8 hours per day or 40 hours per week—will cause an overexposure, even if the actual exposure is within permissible exposure limits.

The *threshold limit value* (TLV) is the exposure, measured as a TWA, set by the American Congress of Governmental Industrial Hygienists (ACGIH) and based on 8-hour workdays and 40-hour work weeks. Owing to differences in standard development, the TLV for a specific substance may vary significantly from the PEL. Both PELs and TLVs tend to be small numbers, measured in parts per million (ppm) or in milligrams per cubic meter (mg/m^3).

The *short-term exposure limit* (STEL) is the exposure workers may safely be exposed to under the following conditions: (a) the exposure is limited to 15 minutes, (b) the exposure at this level may not occur more than four times within an 8-hour workday, and (c) exposures at the STEL level must be separated by at least one hour. STELs must be included in any calculations for the TLV® or PEL.

Chemical levels are considered to be *immediately dangerous to life or health* (IDLH) when they are present in the atmosphere in concentrations that pose an immediate threat to life, would cause irreversible adverse health effects, or would impair an individual's ability to escape from a dangerous atmosphere. Response workers should never be allowed to enter an IDLH atmosphere without adequate personal protective equipment or without proper rescue equipment and personnel on site, who are ready to provide support to injured or trapped workers immediately.

Nature of the Affected Area or Environment–Geology and Hydrology

Near-surface soils affect the impact a spill has on the environment. Tight, nonporous, low-permeability soils tend to limit the diffusion or permeation of spills that migrate downward into the soil. Loose, porous, high-permeability soils offer little resistance to permeation or diffusion. A spill of a highly viscous material (a thick, tarlike substance) will tend to form puddles at or near the spill site on nonporous soils. Given a moderate surface slope, these materials will move slowly, if at all, down the slope or downward into the ground. On the other hand, a low-viscosity material (thin and watery, like fingernail polish remover) spilled on highly porous soil tends to move quickly down the slope and downward into the ground.

Saturated soils tend to retard the movement of water-insoluble materials into the ground. The water filling the spaces between soil particles acts like a dam, blocking the movement of spilled materials as they are pulled downward by gravity. On the other hand, saturated soils tend to accelerate the movement of water-soluble materials by acting as a dispersion pathway. The near-surface water may be connected to, and recharge, groundwater, forming a direct link between spilled materials on the surface and subsurface aquifers.

Basic soils, or soils derived from limestone, also influence how spilled materials affect the environment. Basic soils may assist in neutralizing spilled acids, minimizing the impact of the spill. Karst topography forms over limestone, dolomite, and gypsum and is characterized by sinkholes, caves, and underground drainage. This underground drainage actually allows spilled material to escape from the accident site in miles per hour in underground streams in caves.

Soils are rarely a uniform layer of a single material. Often there are lenses, beds, and other complex structures that may, in some instances, retard the movement of material away from a spill site and, in other instances, accelerate the movement of materials. Time is of the essence in spill response. A few hours' difference in response times can mean the difference between controlling a spill on or near the surface in one or two days or spending months attempting to remediate underground soils and water.

Nature of the Affected Area or Environment–Meteorology

As a general rule, the higher the ambient temperature, the faster spilled liquids tend to evaporate. Low temperatures may allow a spill response team adequate time to effectively contain spilled liquids, creating small downwind hazard areas. Higher temperatures tend to increase vapor pressure and evaporation, providing spill response teams very little time to contain and control liquid spills before a significant downwind hazard area is formed.

Some basic knowledge of atmospheric stability also can help predict the dispersion of contaminants in the atmosphere. A common classification of atmospheric stability is known as the Pasquill-Gifford (P-G) stability class system, which assigns a classification based on factors such as wind speed, solar radiation, and cloud cover. Seven classes are designated by letters: A (for unstable or turbulent conditions) through G (for very stable conditions). Sometimes the numbers 1 through 7 replace the letters. Neutral conditions are class D (or 4).

Very low winds (up to approximately 3 miles per hour) tend to limit the generation of a large downwind hazard area. High winds (above approximately 17 miles per hour) also limit the generation and spread of a large downwind hazard area. Wind speed and direction typically change after sunrise, during the warmest time of the day (approximately 10 AM to 4 PM), and after sunset.

The *Emergency Response Guidebook* (2008), available from the PHMSA Web site, uses a simplified, two-stage stability system to create protective action distances downwind from a spill site. This system consists of day (sunrise to sunset) and night. During the night, the air is generally calmer, corresponding to P-G class D to G (4 to 7) conditions. These conditions cause vapors to disperse less and therefore create a more toxic, but smaller, danger zone. During the day, P-G class A to D (1 to 4) conditions, vapors are generally dispersed by a more active atmosphere. The downwind danger zone will be larger, but generally have a lower toxicity level.

An atmospheric inversion, when warmer air aloft tends to trap cooler air near the surface, will cause large downwind hazard areas to be created quickly. Heavy cloud cover or other inversions will cause vapors or dust released from a spill to be carried miles downwind. This downwind hazard area may force the evacuation of large populations from large areas as well as posing environmental threats.

Nature of Response Operations

Ideally, a properly trained, equipped, and managed spill response team will respond instantaneously to any spill or release of a hazardous material. Unfortunately, time of day, weather conditions, spill location, and the characteristics of the material may prevent or delay response. Specific techniques and equipment used at a spill or release site must be based on actual conditions and the materials involved. In general, the following actions should be taken in any spill situation:

- Identify necessary emergency response equipment and supplies such as PPE, sorbents, hand and power tools, solvents, shovels, pumps, fire extinguishers, and any site-specific equipment or supplies and ensure that it is in good working order and readily accessible.
- Do not underestimate the seriousness of the situation. The first responders may need additional equipment, personnel, and expertise to safely and successfully respond to a situation.
- Control the leak or release as soon as possible. Small spills are always easier to clean up. Stopping the release of a material establishes safer working conditions and limits off-site effects.

- Contain spilled material. Material may escape from a spill site by numerous pathways. Contain vapor clouds, spilled liquids and solids as much as possible as soon as it is safely possible.
- Pump downhill, if possible, to increase efficiency. Working in personal protective equipment is difficult, especially in hot or cold conditions. Increased efficiency will benefit both personnel and the overall response effort.
- Keep hose lines as straight as possible. Again, the increased efficiency will significantly affect spill response operations. Curved or sharply bent hoses limit the efficiency of any pumping system.
- Do not make the situation worse. A spill is a complex situation. Stopping response operations to rescue improperly trained or equipped personnel increases risks to people, the environment, and operations. Using incompatible materials may cause additional spills or hazards such as fire, explosions, or the release of more toxic materials and spread contamination from the original spill site.

Benchmarks and Performance Appraisal Criteria

Several benchmarks exist against which various aspects of spill and release responses may be measured. The most commonly available benchmarks are for responder training, for development of response plans, and for measurements of effectiveness of the response effort.

Training Benchmarks–Sources of Information

For training, the most basic benchmark is set by OSHA in the form of regulatory minimums for response personnel (see the "Personnel Training" section later in this chapter). OSHA very clearly lists the minimum knowledge and skills required to participate in emergency response and hazardous waste operations. Levels of training vary according to the employee's role in an emergency. To supplement these benchmarks, refer to National Fire Protection Association (NFPA) Publication 472, *Standard for Professional Competence of Responders to Hazardous Materials Incidents* (2008). NFPA 472 provides benchmarks for each level of responder, from the first responder at the awareness level up to incident commander, in several performance categories, including analyzing the incident, planning the response, implementing the planned response, evaluating progress, and terminating the incident. NFPA 472 also describes competencies for private-sector specialist employees, technicians for several types of tanks (e.g., tank cars, cargo tanks, and intermodal tanks), and others.

Plan Development Benchmarks–Sources of Information

There are several excellent resources that assist in developing new plans or evaluating existing plans. Many of these resources are available online.

First, the National Response Team has information at www.nrt.org. Of particular interest to planners are these guides:

- *Hazardous Materials Emergency Planning Guide* (NRT-1)
- *Criteria for Review of Hazardous Materials Emergency Plans* (NRT-1a)
- Update of the *Hazardous Materials Emergency Planning Guide*

Using these documents in the order listed provides a historical basis for benchmarking existing plans and illustrates how the planning process and the information sources have evolved. The documents provide a checklist to ensure that plans are comprehensive and complete.

Second, the Environmental Protection Agency's site (www.epa.gov/ceppo) provides significant, useful information, including the NRT-Integrated Contingency Plan Guidance ("One Plan"), which is intended to be used by facilities to prepare emergency response plans. Again, the information can be used as a checklist or benchmark to measure a facility's plan.

Also included on the EPA's Web site is information on local emergency planning committees (LEPC) created by the Superfund Amendment and Reauthorization Act (SARA). Larger facilities should have been coordinating plans with an LEPC since the 1990s. If plans have not been kept up to date, a new facility is being created, or an existing facility is being modified, using local emergency response organizations, as represented on an LEPC, is an excellent way to ensure that a facilities plan meets current standards and work.

Third, many insurance companies, as part of a risk assessment/risk management plan, work with specific facilities to design safe facilities and to develop (and keep current) emergency response plans. Also, many local cooperatives, commodity-specific organizations, and trade associations have prepared standards of good practice that are useful benchmarking tools.

Fourth, and finally, FEMA has developed an independent study course called "Exercise Design" (course number IS-139) that provides excellent information on exercise design, performance, and evaluation and that may be used as a benchmark for both the public and private sectors. This publication also may be used to assess performance and implementation of response drills and exercises.

Measures of Effectiveness

The effectiveness of spill and release response measures varies with the circumstances. For example, if a worker closes the leaking valve on a vat of acetone and the valve ceases to leak, the response is most likely a success. Other factors that could be considered in this example are the following:

- Was the worker or anyone else injured in the response?
- Was the material contained or prevented from spreading in accordance with the facility's emergency response plan?
- Was clean-up equipment readily accessible and in proper working condition?
- If the material leaked onto soil, was it completely removed, as demonstrated by sampling and analysis, or did it simply become an airborne or waterborne spill (caused cross-media contamination)?

The most basic goal of most spill response plans is to safely stop, control, or contain the spill or release and clean up any spilled material (whenever possible). The details of how to accomplish the goal varies from facility to facility and often depends on the characteristics of the material and the quantity of spilled or released material. Benchmarks and performance appraisal criteria should be developed from those details and from any applicable regulatory requirements. In the example above, one very important benchmark of spill clean-up effectiveness is the sampling and analysis of contaminated soil. If analysis of a soil sample revealed contamination in excess of regulatory limits, the clean up was not completely successful—an indication that the spill response plan should be reevaluated.

Operational Readiness

Once plans are determined to be current, comprehensive, and complete, they should be tested. Table-top exercises and other small-group drills are a logical starting place. In preparation for exercises and drills, it may be useful to develop a site-specific checklist to help ensure operational readiness. Some of the following questions may prove helpful in checklist development:

- Do individual workers know how to safely detect and report a spill? Putting a pound of dry ice in a small puddle of vinegar creates a smoking, low pH spill simulation.
- Do workers walk by, or do they investigate? If shift supervisors are responsible for notifying the plant security force that a spill has occurred, are the supervisors capable of transmitting on the same frequency as the security radios? If shift supervisors use an inplant telephone system, can they get from their normal workstation to the telephone quickly enough?
- Equipment should be inspected. Are self-contained breathing apparatuses (SCBAs) usable and equipped with filled cylinders?

Are pumps and hoses stored so they can be immediately used, or do they need to be reconfigured?

- Are high-dollar items such as direct-reading instruments (photo ionization detectors, chemical-specific detectors) and response suits immediately available? If they are kept in locked cabinets for physical security (a smart procedure), where are the keys to the locks?
- Are people ready to respond to emergencies? Can the in-plant response team be mobilized five minutes before the end of a shift on Friday or the day before a holiday? If off-shift personnel are equipped with pagers for rapid recall, will they answer their pagers and respond at night and on weekends? Can in-plant personnel operate safely until off-site emergency personnel respond?
- Is the facility's management prepared to implement an emergency response plan at 2:00 A.M.? Do they have the authority to incur the expense of mobilizing a commercial response team if that is part of the plan? Will they actually call the fire department and emergency medical service, or will they have to wait for authorization from senior personnel?

Once small teams have had the opportunity to practice, the entire plan should be implemented. Are the planned command-site locations realistic, given the nature and quantity of material likely to be involved in a spill? Does the plan assume that more personnel and equipment are available than actually exist? If forklifts are included as response equipment, who will operate them? Are a sufficient number of vehicles available, or will one function take priority? For example, if one in-plant vehicle is scheduled to move injured personnel to the first-aid clinic, one in-plant vehicle is scheduled to move the response team from their normal workstations to the spill site, and one in-plant vehicle is scheduled to move emergency response personnel and equipment, are three in-plant vehicles available, or will one function (e.g., moving the injured) take priority?

During table-top exercises, small group drills, and the first or second full-team exercise, no fault should be assessed for failure to implement the plan. Many failures at this level are due to simple lack of training or awareness of the implications of the training. Honest critiques, pointing out deficiencies in implementing the plan, should be conducted to ensure that all personnel know what their individual, specific roles are. A lab technician or part-time security guard may be the initial incident commander and should understand exactly what that means. Benchmarking, or measuring the success of implementing the emergency response safely and efficiently, means that everyone involved should be able to effectively perform their emergency response role, from reporting the spill on a radio to obtaining and donning the correct PPE and plugging leaking equipment.

Performance Appraisal Criteria

Performance appraisals are essential for the effective management of an incident and for the evaluation of worker effectiveness, techniques, and equipment and supplies used for emergency response. Appraisals both during and after the incident (whenever possible) and during and after exercises and drills help improve the effectiveness of the response and provide valuable information for future responses. Once specific goals or actions have been identified in the response plan, devise a simple way to measure their effectiveness, such as a checklist or any other convenient format (e.g., a narrative).

Performance appraisals conducted during exercises demonstrate the strengths and shortcomings of the emergency response plan—such as the use of inadequate equipment, the need for further employee training, or the need for improved communications during an incident. For example, the emergency response plan of a fictitious company directs a particular employee to close a particular valve to stop a release. On the day of the planned exercise, the employee was absent, so the valve was not closed. This fact would have been noted during a post-exercise performance evaluation and the corrective measures implemented.

Cost Analysis and Budgeting

Preparing for 24-hour spill response—personnel selection and training, medical surveillance, personal protective equipment, increased staffing for immediate, around-the-clock response—is a major expense. Before any resources are committed to spill response, a risk determination and a cost-benefit analysis should be performed. What is the likelihood that a spill or release will occur? Consuming thousands of dollars and hundreds of man-hours to prepare for an event that is unlikely to occur may not be justified. On the other hand, what are the consequences of a spill or release? Even in the unlikely event of a spill, severe consequences may require some type of immediate response.

The accidents at Three Mile Island, Pennsylvania, and Bhopal, India, demonstrate the disastrous consequences of improperly evaluating a seemingly small, unlikely event. Do the materials known to be present or likely to be involved in a spill or release require immediate response? If oil from a failing tank is contained within a dike, responders have some time before the oil is recovered. On the other hand, an oil spill from a ship or shore-based facility can result in tens of thousands of dollars in damages if an effective spill containment and control plan is not implemented within minutes. A small chemical reactor in a laboratory may release only a few liters of a spontaneously combustible catalyst. The ensuing fire may destroy thousands of dollars of equipment if it is not controlled immediately. Perhaps designing the plant to operate on a lower inventory of hazardous materials or using diluted, less hazardous materials may be a more efficient use of resources.

Assessment of Risk

There are numerous computer programs and planning processes that can assist in predicting the spread of a hazardous material and its effects on people, property, and the environment. The following discussion is not intended to replace these planning tools, but rather to present additional concepts that can valuable in determining the need for developing a spill or release response plan.

Damage to People

Human health and safety are the prime concerns before and during the response to any type of spill or release. Spectacular, world-scale events such as the incidents at Chernobyl, Ukraine, or Bhopal, India, cause direct, measurable loss of life and damage to human health. Even less-publicized events, such as transportation accidents in the United States that released chlorine or ammonia, have killed or injured people at the site and downwind from the spill or release site. Response workers have also been at risk. During the sarin (an extremely toxic chemical) attack in the subway in Tokyo in 1995, significant numbers of response workers were adversely affected while attempting to aid injured commuters. One spectacular event, a boiling liquid–expanding vapor explosion, or BLEVE, has killed responders minutes or hours after accidents involving railroad tank cars of propane.

Risk assessment during a chemical spill response must begin before the incident. Basic questions need to be asked and answered. What types of materials are present or likely to be present? What quantities of materials are involved or likely to be involved? Are responders trained to recognize the presence of these materials and amounts and the hazards involved in the response? Do the response workers have the equipment and training to work with these materials under poorly controlled situations that typically exist during the initial phases of a response? Do the response workers actually know how to use their equipment during adverse conditions?

Planning saves lives and protects health. Before materials are brought to a site, plans should be prepared and practiced for normal operations as well as spills or releases. Even if a facility is not required to comply with the provisions of section 112(r) of the Clean Air Act, using it and the implementing regulations at 40 CFR 68 (Risk Management Program) may indicate shortfalls in planning for the safe storage and use of a specific material. The off-site consequence analysis (OCA) in 40 CFR 68 is one way to plan for possible off-site or downwind consequences of a spill or release of material. Environmental laws and safety regulations such as the Superfund Amendment and Reauthorization Act (SARA) Title III, also known as the Emergency Planning and Community Right-to-Know Act (EPCRA), and the OSHA process safety management standard, 29 CFR 1910.119, should be studied not just for legal compliance but also from the respond-on-Sunday-afternoon-in-90°F-weather or the Friday-night-in-freezing-rain perspective.

Consider the materials expected to be present; are spills or releases likely to generate flammable atmospheres? How will response workers control the release and contain released materials if flammable vapor clouds are present? Are the materials, in the quantities likely to be involved in a spill, expected to generate vapor clouds above the permissible exposure level or threshold limit value? Will workers be expected to wear air-purifying respirators or air-supplying respirators (SCBA or air lines with escape bottles)? In addition to off-site consequence analysis, the on-site procedures and techniques to prevent a release and respond safely, efficiently, and quickly if a release occurs, should be closely examined to ensure that response workers have the tools, knowledge, and skills to complete their assigned tasks.

Damage to Property

Just as spills and releases pose risks to people, they also pose risks of damage to property. A spill of a reagent or raw material represents not only the loss of that product but also of adjacent materials in storage, awaiting processing or use. Concentrated acetic acid leaking from a feed line into a processing building was allowed to leak into the soil. The spill created not only a dangerous situation to people but also corroded through the fire main to the building, causing it to fail. The failure of the fire protection system forced the closing and evacuation of the processing building. The loss of the product was only a minor expense compared to the unplanned, forced shutdown; replacement of the fire main; and restart of the system. A spill of methyl ethyl ketone peroxide resulted in a fire. The fire destroyed thousands of dollars of spill response equipment that was stored in the hazardous materials warehouse, near where it was expected to be used. Planning and practicing the plan would have indicated the raw material and the response equipment were too close to each other. Again, the loss of the product was only part of the total loss.

Spills and releases damage more than just raw materials. Loss of operating capability can greatly exceed the cost of the materials that were spilled—and this involves any type of material, not just hazardous materials. For example, heated sugar syrup was kept in insulated tanks in a manufacturing plant. Since sugar syrup is not a "hazardous material," there was no planning for any spills or responses. When a transfer line was ruptured by a forklift, the syrup immediately overflowed the poorly designed containment system and oozed from the warehouse into the manufacturing part of the plant. Because there were no provisions for containing this hot, viscous mass, it was allowed to cool before clean up began. Unfortunately for the plant, the only door between the warehouse and the manufacturing section was in the path of the spill. Even worse, that one door had been effectively sealed shut for three days. In the rush to restart manufacturing, forklifts moving raw materials from the warehouse were driven over the partially cleaned floor. The second clean up, removing crystallized sugar syrup from all parts of the plant, took longer and cost more than the initial, poor response and greatly exceeded the cost of the syrup. Even more severe consequences may result from the release of truly "hazardous" materials.

Finished materials may also be at risk. Solvents and building maintenance materials were spilled and spread over hundreds of thousands of dollars of finished aircraft parts during a fire. Unpacking the parts, cleaning and repackaging them, and disposing of the contaminated packaging not only closed the facility but cost more than the products and initial fire and hazardous materials response. Planning the storage of hazardous materials, in the amounts typically present in the plant or facility, makes spill response quicker, safer, more efficient, and saves money.

Critical infrastructures can also be damaged during spills or releases. Sewage treatment plants may be forced to close to prevent petroleum products, activated sludge-killing materials, and heavy metals from contaminating the plant, killing all the bacteria, and being released into the environment. Highways and railways may have to be closed during spill response work to protect workers and allow equipment to operate on site. A transportation spill or a release from a facility near a bridge may affect the community for extended periods. Again, there must be plans to safely, quickly, and efficiently respond to spills.

Damage to the Environment

Critical habitats can be severely damaged during hazardous material spills. Petroleum products spilled into or onto wetlands can destroy precious, nearly irreplaceable environmental assets, as well as consume thousands of dollars in clean up and remediation. Love Canal is one example of how releases of hazardous materials damaged the environment to such an extent that people could no longer safely live in their homes. Leaking underground storage tanks are another example of hazardous material releases damaging the environment—in this case groundwater—and requiring extensive and expensive remediation efforts.

Conclusion

There are a variety of commercial planning tools, laws, and regulations that can assist in estimating the damage to people, property, and the environment from hazardous material spills and releases. Spill response plans should address not just compliance with legal requirements and costs of response, but should also address safety concerns in a realistic, ethical manner.

Best Practices in Environmental Management–Spill Prevention and Response

Spill Prevention and Response Plans

Spill prevention, planning, and response programs or plans are required by several federal standards. In many cases, the development and implementation of one comprehensive plan will satisfy all of the applicable federal regulatory requirements. For example, if a facility has a contingency plan, as required by EPA regulations, and that plan addresses all elements required under the HAZWOPER standard, the contingency plan may be used to satisfy the HAZWOPER emergency response plan requirement.

Employers who evacuate employees from the facility during an emergency and do not allow employees to help in managing the emergency do not have to have an emergency response plan, as required by the HAZWOPER standard, as long as they provide an emergency action plan that complies with the applicable regulation (e.g., 1910.120, 1926.35).

The following is a partial list of federal standards and regulations that require some type of emergency prevention, planning, or response plan or program. This list is not inclusive; however, it is intended to demonstrate the wide range of regulations that may require a plan.

- DOT (49 CFR): Part 130—Oil Spill Prevention and Response Plans
- EPA (40 CFR): Part 68—Chemical Accident Prevention Provisions
- OSHA (29 CFR): ***General Industry:*** 1910.38—Emergency Action Plans, 1910.119—Process Safety Management of Highly Hazardous Chemicals, 1910.120—Hazardous Waste Operations and Emergency Response, 1915.502—Fire Safety Plan, 1917.30—Emergency Action Plans, 1918.100—Emergency Action Plans ***Construction:*** 1926.35—Employee Emergency Action Plans, 1926.64—Process Safety Management of Highly Hazardous Chemicals, 1926.65—Hazardous Waste Operations and Emergency Response, 1926.150—Fire Protection

Nearly all industry-accepted best practices stress incident planning, written plans, and practice exercises as essential elements of a successful emergency response. Best practices include general concepts such as planning, PPE, mitigation, and decontamination, but these must always be adapted to provide for any site-specific conditions and contingencies.

Several references are available to assist organizations in the development of site-specific best practices. Some of these are listed here:

- NFPA 471 *Recommended Practice for Responding to Hazardous Materials Incidents*, 2002 edition

- NFPA 1600 *Standard on Disaster/Emergency Management and Business Continuity Programs*, 2010 edition
- National Response Team NRT-1 *Hazardous Materials Emergency Planning Guide*, 2001 edition
- OSHA *Best Practices for Hospital-Based First Receivers of Victims from Mass Casualty Incidents Involving the Release of Hazardous Substances*, 2005 edition

The basic steps in developing an effective spill prevention and response plan that incorporates industry-accepted best practices include performing a hazard assessment, identifying ways to eliminate or reduce the hazards, developing plans and procedures to be taken in the event of an emergency, and training personnel in their particular role in an emergency and in execution of the plan. To be effective, spill prevention and response plans should be site-specific. Because all facilities are not necessarily subject to all regulations, and because the regulations have varying requirements, it is not possible to provide one plan that fits all facilities and circumstances, but the plan elements discussed below will provide a good foundation for most facilities.

Hazard Prediction Model

General Behavior Model (GEBMO) is a hazard prediction model developed by Ludwig Brenner. Given a particular set of circumstances and conditions, predictable outcomes will result. GEBMO can be used to plan responses to virtually any situation: a broken syringe or vial in a biohazard lab, small-volume spills of low-hazard material, or large-volume spills of high-hazard material. As shown in Figure 1, GEBMO considers seven factors. GEBMO is a valuable tool for predicting outcomes when completing a hazard assessment.

Hazard Assessment

Hazards may be separated into three basic types: physical, chemical, and natural. Physical hazards are those that pose a threat to human physical well-being. Examples of physical hazards are fire, explosion, noise, slips, falls, release of hazardous energy (e.g., electrical, steam, pressurized hydraulic or other fluids), entrapment, heat and cold, and others. Some physical hazards, such as fire or explosion, may cause a spill or release of hazardous materials or hinder response efforts.

Chemical hazards, radiation, and biological agents pose an external or internal physiological threat to one or more parts of the human body. Chemical hazards can cause short- and long-term health and physical effects, the severity of which depends on several factors, such as route of entry, toxicity, amount, and duration of exposure. Poisons, corrosive materials, anthrax, and asbestos are examples of chemical hazards. During emergency response and mitigation of a spill or release, personnel must take the appropriate precautions to protect themselves from the chemical hazards associated with all of the spilled or released material(s).

Natural hazards are those found in nature and that either affect such living things as animals and insects or are caused by or exacerbated by electrical storms, earthquakes, and wildfires. Natural hazards may cause or contribute to a spill or a release or may impede emergency response and clean-up efforts.

The hazard assessment should begin with a walk-through of the site or facility. Next, determine and

Stressing Event Occurs
(thermal, chemical, mechanical, human)
↓
Container Breach Occurs
(detonating, rapid release, leak)
↓
Hazardous Materials or Energy Escapes
↓
Hazardous Materials or Energy Engulfs Danger Zone
(dispersion: path, pattern, distance)
↓
Hazardous Materials or Energy Impinges on Receptors
(transient, lingering, permanent)
↓
Hazardous Materials or Energy Harms Receptors
(thermal, chemical, radiation, etiologic, mechanical)
↓
Remedial Efforts Attempted
(first aid, fire fighting, chemical decontamination)

FIGURE 1. General Behavior Model (GEBMO)

document the actual or potential chemical hazards, including chemical names, locations, quantities, and packaging (e.g., bulk and nonbulk containers, underground and aboveground storage tanks, process vats, and compressed gas cylinders). In the event of an emergency, some scenarios to consider are:

- Will a spill or release harm people or the environment or both?
- If spilled, can the material reach a body of water?
- If the released materials commingle, what will the results be?
- Is it likely that a natural disaster, such as an earthquake or hurricane, will result in a release of material?
- Will response efforts be hindered by physical hazards such as confined spaces, fire, release of electrical or other hazardous energy, flooding, etc.?
- Will off-site significant structures, such as buildings, bridges, tunnels, water treatment plants, schools, houses, and the like, be affected by a release?
- Is there a downwind hazard, and if so, how far does it stretch?
- In the event of a major catastrophe, what is the likelihood that personnel evacuation would be hindered?
- What off-site resources (e.g., fire departments, hazmat teams, rescue squads, commercial response companies) are available that could respond in a timely manner?
- Which federal, state, and local agencies require notification during or after a spill or release?
- Does the facility have some response capability? If so, what types or sizes of spills or releases can personnel manage? Have personnel been properly trained? Is the correct equipment available?

After the hazard assessment has been performed, decide what procedures or actions can be used to reduce or eliminate the actual or potential hazards. The three most common hazard-reduction tools are engineering controls, administrative controls (including safe work practices), and the use of personal protective equipment (PPE). These tools are primarily aimed at increasing worker health and safety, but are very valuable in reducing the likelihood of an accidental spill or release because a safer workplace results in fewer accidents. The responsible party should try one or more of the following:

- Engineering Controls: Engineering controls are usually the most effective measures because they are used to control the hazard at its source. If possible, design the equipment or process so that it is less hazardous. This is sometimes accomplished by substituting a hazardous material with one that is less hazardous. Some engineering controls are quite simple. For example, enclosing a hazard may remove it completely. Barriers, spill containment, blast shields, automatic monitoring and shut-off equipment, and local ventilation are other ways to reduce or eliminate hazards.
- Administrative Controls: Administrative controls are measures that are designed to reduce employee exposure to hazards. Common measures include rotation of workers, exercise breaks, shorter shifts, heat/cold stress management, the use of additional relief workers, and others. Administrative controls are often used with other controls, such as PPE, that more directly prevent or control exposure to the hazard.

Safe work practices are often considered forms of administrative controls. These controls are generally presented as employer-specific and operation-specific rules, such as written operating procedures, the use of buddy systems, training, use of permits (e.g., hot work and confined space permits), warning signs, alarms, and the like.

- Personal Protective Equipment: PPE should be used as the last resort (after engineering controls and administrative controls) to protect personnel from hazards at the site or facility. The use of PPE requires its own hazard assessment to determine what kind of equipment is needed to protect against the hazards of the job. It is very important that employees are trained on the selection, use, and maintenance of PPE. They must understand that PPE does not eliminate the hazard. If the equipment is not the correct equipment for the job, or if it fails, exposure to the hazardous material(s) will occur. Again, keeping workers safe will help reduce accidents, including spills and other surprise releases.

It is very helpful to elicit worker input during this stage of emergency planning. Employees who actually work with the materials often have valuable suggestions that may greatly assist in developing hazard analysis and ways to mitigate those hazards.

Develop Written Plans and Procedures

Once the hazard analysis is complete and hazard reduction tools have been considered and implemented, as indicated, the written plan may be developed. The plan should be reviewed and evaluated every year and updated, as necessary. At minimum, the following plan elements should be addressed:

Facility or Site Description. This section should include the facility address and a general description of facility function. It should include topography (if applicable), the surrounding population, facility layout, off-site concerns (e.g., waterways, downwind hazard zones, significant structures), and a general description of the types and quantities of hazardous materials on site.

Personnel Roles and Communication. This section should describe the roles all personnel will play in the event of an emergency. Roles may be described by department (e.g., Maintenance Department or Radiation Department), job function (e.g., mechanic or administrative), title (e.g., vice president or safety manager), and/or by name. Lines of personnel authority and a description of how communication will take place should also be included.

Describe medical and security duties for those employees who are to perform them. The role of some personnel or departments may be simply to evacuate. If that is the case, clearly state that in the plan. List who will be responsible for ensuring all employees have been safely evacuated and who will be responsible for federal, state, and local notifications. Also include in the plan the names or job titles of persons who can be contacted for an explanation of personnel roles and responsibilities or for questions about the plan.

Evacuation Routes and Procedures. Obtain a site map or diagram of the facility. On the map, mark evacuation routes, exits, locations of emergency supplies and equipment, locations of emergency shutoffs, floor drains, bodies of water, safe meeting places, hazardous locations, and any other information that would be pertinent in an emergency. Depending on the size and type of the facility, a lockbox located outside the facility, which contains MSDSs, a site map, emergency contact information, and facility keys, may be required by the local fire department. If such a lockbox is used, be sure to note its location on the map so that, if necessary, local responders may be directed to the box by the person reporting the emergency. Post the map in several locations throughout the facility, as appropriate.

Describe the conditions and procedures for reporting incidents to local, state, and federal governmental agencies. At some facilities, workers may be trained to respond to small spills and leaks, but also may depend on outside sources for help with management of larger spills. Because the meanings of *small* and *large* are relative, be sure to define those terms in the plan. Reporting procedures should include initial emergency reporting as well as any required written or follow-up post-incident reports.

Develop written procedures to be followed by employees who are to remain behind to operate or shut down critical plant operations or equipment before they evacuate. Develop procedures to account for all employees after an emergency evacuation has been completed and what to do if not all personnel can be accounted for.

Emergency Procedures. In this section, clearly describe, step by step, all procedures that should be used during a spill or other emergency involving hazardous materials. Each topic should be addressed in logical steps or bulleted lists so that during an emergency, when stress is likely to be high, the procedures are very clear and easy to follow. Some of the procedures may be redundant, but this section is meant to be clear, simple, and easy to follow during emergencies. For some facilities, the emergency procedures may consist only of two steps—evacuate all personnel and call 911—but for most facilities, the procedures will be more in depth. For very large facilities with multiple types of concurrent operations, a flow chart may be useful for showing how emergencies in one area do or do not affect other areas of the facility. These facilities may also benefit from having several smaller emergency response plans in various areas of the plant, with a master plan maintained by the administration or safety office.

Clearly describe the following, as applicable to the facility or site, as well as any other site-specific procedures that are needed:

- Emergency alerting and notification procedures: Outline how the emergency will be communicated to other facility personnel and to outside agencies, if necessary.
- Security: Spell out how to secure and control the spill or release site and how to secure and control the facility or any off-site locations.
- Evacuation/safe distances: Delineate where and by what route personnel are to go so they are a safe distance from the release.
- Outline facility, process, and equipment shutdown procedures.
- Lay out specific steps and methods to stop, contain, or confine the spill or release, including the necessary PPE and emergency equipment and supplies.
- List the monitoring frequency and methods.
- Emergency medical treatment and first-aid procedures: If medical treatment and first aid are to be administered only by trained outside professionals, state that; if injuries may be treated by facility personnel, this section may contain procedures for categories of injuries, such as burns, cuts, punctures, and others
- Decontamination procedures: Detail routine and emergency decontamination procedures.

Post-Response Actions. Once the spill or release emergency response and clean up is complete, it is very useful (and required by some regulations) to perform an incident investigation and to critique the response actions. This investigation is a tool that is useful for discovering hazards that were either inadequately addressed or completely missed in earlier stages of planning. The ultimate purpose of accident and incident investigation is to make the system better—to uncover and correct the root cause of the problem and to prevent future occurrences—not to place blame.

Another post-response action that may be required by federal or state regulations (e.g., the HAZWOPER standard and others) is a follow-up report. Consult the applicable agency or regulation(s) to ensure that the required information is submitted in a timely fashion.

Personnel Training

Before any spill response or other emergency plan is implemented, all affected personnel must receive training, the level of which depends on the employees' responsibilities during an emergency. For employees who are not likely to have contact with hazardous materials and who will have no responsibility other than to evacuate, minimal training is needed. These people need to be trained to understand the general contents of the plan and when and how to evacuate. Also, an appropriate number of people should be trained to help with the safe evacuation of employees during an emergency.

As the level of responsibility goes up, so does the amount and type of training. At a minimum, OSHA's *Hazard Communication Standard* training will apply, and depending on the type of site or facility, it is likely that training requirements of the HAZWOPER standard will also apply. Most hazardous waste site workers (including those who respond to emergencies at those sites) will need 40 hours of training plus an annual refresher, as detailed in 29 CFR 1910.120(e).

Employees who respond to hazardous material spills and releases at sites other than hazardous waste sites are required to have the appropriate level of training found in 29 CFR 1910.120(q). The five levels of training (which also require an annual refresher) and a brief description of duties found in this section include the following:

- First responder awareness level: These are workers who are likely to witness or discover a spill or release and whose only responsibility is to notify the proper authorities of the release.
- First responder operations level: These are workers who respond initially to help protect nearby people, property, and/or the environment from the effects of the release. They do not specifically try to stop the release, but instead try remotely to contain or stop the spread of the release.
- Hazardous material technician: This is a worker who more aggressively tries to stop the release by patching, plugging, or using some other method.
- Hazardous material specialist: This is a worker whose duties are similar to the hazardous material technician. The specialist has more of a specific knowledge of the material or process and provides support to hazardous material technicians. They also have the authority to act as the site liaison with federal, state, local, and other government authorities regarding site activities.
- On-scene incident commander: He or she assumes control of the incident scene and is able to implement the employer's emergency response plan and incident command system and local emergency response plan. The commander also has a thorough knowledge and understanding of the risks and hazards involved when employees are working in PPE (including decontamination procedures). In addition, the on-scene incident commander must have knowledge of the state emergency response plan and of the federal Regional Response Team.

At a minimum, personnel should be trained when the plan is first developed, whenever worker responsibilities or procedures change, and whenever the plan is changed or revised. For information on training benchmarks, see the "Training Benchmarks—Sources of Information" section earlier in this chapter.

Practice drills are recommended to familiarize workers with the procedures and to reinforce behaviors that are necessary during emergencies. Critiques of the drills can be used to discover and improve plan weaknesses.

Medical Surveillance

Medical screening and medical surveillance are two basic, distinct methods used to monitor and help protect worker health. The purpose of medical screening is the early detection, diagnosis, and treatment of an individual worker who has been exposed and adversely affected by an incident. As in pre-employment screening, the purpose of medical screening is to provide a baseline of the worker's current medical condition so that later changes resulting from workplace exposures can be detected. The main purposes of medical surveillance are to detect, then eliminate, the underlying causes of specific, work-related health problems and to detect exposure trends, often across groups of workers.

Numerous OSHA standards require some type of medical screening/surveillance. See OSHA's Web site (www.osha.gov) for more information and additional medical screening/surveillance resources. Personnel engaged in hazardous waste or emergency response operations must be covered under a medical surveillance program. Generally speaking, the employer must institute a medical surveillance program for any of the following employees:

- employees who are or may be exposed to hazardous substances or health hazards at or above the established permissible exposure limit, published exposure level (without regard to the use of respirators) for 30 or more days a year
- all employees who wear a respirator for 30 days or more a year
- all employees who are injured, become ill, or develop signs or symptoms as a result of an overexposure involving hazardous substances or health hazards from an emergency response or hazardous waste operation
- employees who work with specific substances (e.g., lead, arsenic, benzene, and many others)
- employees who are members of hazardous material teams

Personal Protective Equipment

The classic hierarchy of safety techniques is engineering controls, administrative controls, and personal protective equipment (PPE). Engineering controls are physical modifications of the work site to protect workers. During spill or release responses, engineering controls will be extremely difficult to establish. By the very nature of a spill or release, engineering controls have either failed or cannot be established until the response action is nearly complete. Similarly, administrative controls, although helpful in setting safe work conditions, will not provide adequate protection to response workers. Therefore, personal protective equipment, generally the last choice in protecting workers, becomes the prime, and sometimes the only, reliable way to protect workers during the initial phases of spill responses.

Table 1 lists the four levels of protection specified in the *Hazardous Waste Operations and Emergency Response* (HAZWOPER) standard, published at 29 CFR 1910.120, Appendix B. The table also lists selection criteria and some disadvantages for each level of protection. There are several factors that greatly enhance the safety provided by PPE. These include, but are not limited to, the following:

- Chemical compatibility: Any item of PPE—body protection, gloves, boots, accessories—must be resistant to the materials present or likely to be present in a spill. There are two measures of compatibility: breakthrough time and permeation rate. Breakthrough time, simply put, is the time it takes an item of PPE to leak. This time interval between first contact on the outside and detection of the material on the inside of the PPE is critical to proper selection. Some materials will cause virtually instantaneous failure of PPE. Obviously, this provides no protection to workers. The longer the breakthrough time, the better the PPE is suited for a particular response. The second measure of compatibility is the permeation rate. Again, simply put, this is the rate PPE leaks, once breakthrough has been achieved. The lower the permeation rate, the better the protection provided to workers. Virtually all manufacturers provide breakthrough times and permeation rates for their particular brands and models of PPE. Do not use equipment without this information. Additional sources of information include NIOSH, the National Fire Protection Association (NFPA), and numerous commercial spill response manuals.
- All levels of PPE should be considered a complete ensemble. If the fabric of a Level A suit provides hours of breakthrough time when exposed to a specific chemical, but the facepiece fogs instantly when exposed to the same material, the ensemble fails. Outer gloves and boots or boot covers must provide the same breakthrough time and permeation resistance as the suit.
- Size: A 100-pound, 5-foot-tall worker cannot safely wear the same PPE that fits a 250-pound, 6-foot-tall responder. PPE selection is often based solely on chemical compatibility. Workers who cannot safely move on a spill site are not protected—they are just wearing a chemical resistant wrapping that creates slip, trip, and fall hazards.
- Suitability for the task: Full-facepiece respirators worn under a chemical protective suit with a hood and built-in facepiece provide excellent chemical protection but effectively destroy all peripheral vision. Most Level A suits, properly sized, will not allow the wearers to see their feet or what they are walking on. PPE must address all hazards on the spill site. Workers who need corrective lenses may not be able to achieve a proper fit with some half-mask respirators. Full-facepiece respirators with spectacle kits inside the mask may be required.
- Training: Life is different and difficult inside PPE—even something as simple as Level C splash suits and half-mask respirators. Breathing is more difficult and voice communications are limited. Workers must be comfortable enough and confident enough in PPE to work safely and efficiently. This comfort and

TABLE 1

Personal Protective Equipment

Level	Selection Criteria	Respiratory Protection	Body Protection	Limitations
A	• The greatest level of eye, skin, and respiratory protection is required • Substances with a high degree of hazard to the skin are known or suspected to present, and skin contact is possible • Operations are being conducted in confined, poorly ventilated areas and the absence of conditions requiring Level A have not yet been determined	Pressure-demand, full-facepiece SCBA or pressure-demand supplied-air respirator with escape SCBA, NIOSH-approved	• Totally-encapsulating chemical protective-suit • Inner and outer chemical-resistant gloves • Chemical-resistant, steel-toe and shank boots Optional items: • Coveralls • Long underwear • Outer boots or boot covers • Hard hat (under suit)	• Fully-encapsulating suit material must be compatible with the substances involved • Movement is restricted • Induces heat stress
B	• The highest level of respiratory protection is necessary, but a lesser level of skin protection is needed. • The atmosphere contains less than 19.5% oxygen • The presence of incompletely identified gases are indicated by a direct-reading instrument, but they are not suspected of being harmful to the skin	Pressure-demand, full-facepiece SCBA or pressure-demand supplied-air respirator with escape SCBA, NIOSH-approved	• Hooded, chemical-resistant clothing (hooded one- or two-piece suit; disposable chemical-resistant overalls) • Inner and outer chemical-resistant gloves • Chemical-resistant steel toe and shank boots Optional items: • Coveralls • Long underwear • Outer boots or boot covers • Hard hat (under suit)	• Use only when exposure to materials will not adversely affect the skin • Suit, outer gloves, and boots must be chemically compatible with materials present • Induces heat stress
C	• The concentration(s) and type(s) of airborne substance(s) are known, and the criteria for using air-purifying respirators are met • Atmospheric contaminants, liquid splashes, or other direct contact will not adversely affect or be absorbed through the skin • The types of air contaminants have been identified, concentrations measured, and an air-purifying respirator is available that can remove the contaminants	Full-face or half-mask NIOSH-approved respirators	• Hooded, chemical-resistant clothing (hooded one- or two-piece suit; disposable chemical-resistant overalls) • Inner and outer chemical-resistant gloves • Chemical-resistant steel toe and shank boots Optional items: • Coveralls • Long underwear • Hard hat (under suit)	• Atmospheric concentrations of chemical must not exceed IDLH levels • The atmosphere must contain at least 19.5% oxygen • May not protect workers from sudden, drastic changes at the work site
D	• A work uniform providing minimal protection; used for nuisance contamination only • The atmosphere contains no known hazards • Work functions preclude splashes, immersion, or the potential for unexpected inhalation of, or contact with, hazardous levels of any chemicals	None required	• Coveralls • Chemical-resistant steel toe and shank boots Optional items: • Gloves • Hard hat • Safety glasses or chemical splash goggles • Face shield • Escape mask	• This level should not be worn in areas where chemical exposures are likely • The atmosphere must contain at least 19.5% oxygen • May not protect workers from sudden, drastic changes at the work site

(*Source*: National Institute for Occupational Safety and Health 1985)

The standard for personal protective equipment (PPE) is at 29 CFR 1910.120, Appendix B. It is important to note that this appendix includes the statement: "... Combinations or personal protective equipment other than those described for Levels A, B, C, and D protection may be more appropriate and may be used to provide the proper level of protection."

confidence comes only through repeated training exercises, under conditions likely to be encountered during spill responses. Training in the actual suits to be worn during a spill response may damage the suits. It may be necessary to dedicate specific suits to training use while saving other suits, of the same model, for actual responses.
- Disposable versus reusable: Reusable PPE may offer some long-term cost savings. But after exposure to specific materials, it may not be possible to completely decontaminate reusable PPE. Given that PPE is often stored for weeks or months between responses, small amounts of contaminants missed during decontamination may permeate through suits, gloves, etc., exposing responders as soon as they don the "protective" equipment.

Spill Kits

Spill kits can solve many problems in an emergency. While planning the response, two important questions to be answered are (a) Who will use the kits? and (b) How big is the potential spill? A 5-gallon bucket of sorbents will not control most spills from a rail car. An 85-gallon overpack drum full of rubber suits, goggles, shovels, and sorbents is useless in the hands of unskilled or untrained personnel.

Components of spill kits can be divided into two sections—PPE and containment and recovery tools. PPE should include head, body, hands, and feet protection. Relatively inexpensive coated and hooded Tyvek or PVC coveralls may be sufficient. Inner surgeon's gloves and long gauntlet outer gloves and boot covers, if resistant to the spilled chemicals, may complete the skin protection equipment. Respiratory equipment will range from half-mask disposable respirators to positive-pressure, full-facepiece SCBAs, depending on the vapor pressure of the spilled material, the toxicity of the spilled material, and the location of the spill. Other items include splash aprons, goggles, hard hats, and thermal protection, depending on the nature of the spill.

Containment and recovery tools are sorbents (absorbents and adsorbents), diking and patching materials, tools to deploy and recover them, and containers. Again, the type and amount of materials depends on the vapor pressure of the spilled material, the toxicity of the spilled material, the size of the anticipated spill, and the location of the spill. Materials generally useful on spills include the following:

- oil dry or some type of expanded clay (in 40- to 50-pound bags): used for general purpose diking and solidifying liquids
- granular activated carbon (in 40- to 50-pound bags): used to absorb and adsorb vapors and liquids from spill materials with high vapor pressure
- garden lime (in 50-pound bags): used to neutralize and solidify spilled liquid acids
- food-grade granular citric acid (in 50-pound bags): used to neutralize spilled liquid bases
- shovels, scoops, dust pans, and brooms to apply the material and to recover it once it has been used
- absorbent/adsorbent pads and pillows
- drums to hold everything ready for use and to contain used sorbents
- containment and sorbent boom if a spill is expected near water or if drains need to be blocked off
- plastic bags to contain used sorbent materials
- DOT-specification drums to contain and transport spill clean-up materials
- overpack drums if leaking drums are included in the plan
- warning barricades (tape, cones, portable barriers)
- documentation on transporting hazardous wastes—labels, manifests, and placards

The previous list is not exhaustive. Many products such as corn oil, vinegar, household hydrogen peroxide, liquid chlorine bleach, baking soda, soda ash, and sodium carbonate may be useful in certain cases. As mentioned previously, the components of the spill kit should be based on a realistic assessment of likely spill situations and the size and competence of the crew using the kit.

Site Layout

A spill or release site is typically divided into work zones to provide better control of the incident and to increase worker safety. In very general terms, a spill response contains three zones, as shown in Figure 2.

Hot Zone: Also called the work zone or the exclusion zone, it is the area of highest known or anticipated contamination. There may be areas of higher contamination or different types of contamination within the hot zone. For example, if a process building was damaged during a fire and explosion, each reactor vessel or broken pipe may be designated a separate high-risk area within the hot zone. Each drum or pallet of drums released from a truck or train may be designated a high-risk area, or there may be different risk areas (flammable, toxic, corrosive, oxidized) within the overall hot zone for a transportation accident. All personnel not wearing the proper personal protective equipment should be barred from entering the hot zone.

Warm Zone: Also called the contamination reduction zone or buffer zone, it is an area of reduced contamination or potential for worker exposure. Air monitoring to determine evacuation distances and soil and water sampling to determine the extent of contamination are significant activities conducted within the warm zone. As with the hot zone, only personnel wearing the proper personal protective equipment should be allowed to enter the warm zone.

Cold Zone: Also called the support zone or administrative zone, it is an area of no known contamination or no anticipated exposure to hazardous materials. The command post, first-aid station, equipment storage area, maintenance areas, media briefing area, and break areas are typically located within the cold zone. Keeping unwanted or unnecessary personnel from the cold zone can become a major activity if security is not maintained. Maintaining security on the site can be very difficult in urban areas, production facilities, and research laboratories.

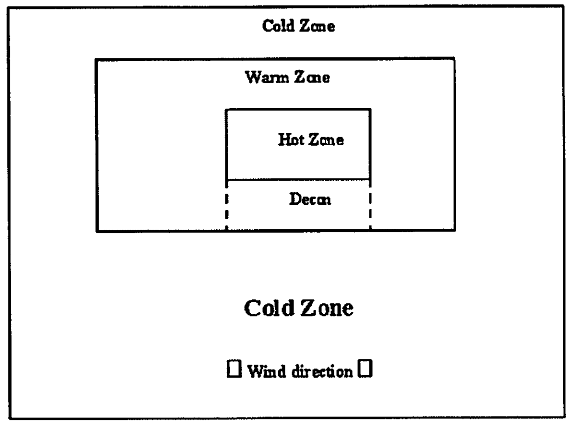

FIGURE 2. Spill response work zones (*Source*: NIOSH 1985)

Decon: Also known as the contamination reduction corridor or the personnel/equipment decontamination station, the decon area is where chemical contamination is removed from personnel, tools, instruments, and equipment before any person or any item is allowed to enter the cold zone. Decon, discussed elsewhere in detail, is a sizable subject. In general, the same level of personal protective equipment is used on decon and in the hot zone: Level A decons Level A, Level C decons Level C. Occasionally, it may be possible to step down one level: Level B decons Level A, Level C decons Level B. Decon personnel should always wear at least Level C. Improper or incomplete decon endangers personnel, property, and the environment by allowing contamination to escape into the general, uncontrolled environment. On multiple-day responses, every reasonable attempt should be made to keep decon uphill and upwind from the hot zone.

Wind Direction: If at all possible, the site should be established so that the wind blows from the command post in the cold zone, through decon, onto the hot zone. On the downwind side of the hot zone, the warm and cold zones should be large enough so that personnel outside the spill response site are not in risk of contact with either atmospheric (airborne) or physical (liquid, solid) contact with chemical contaminants.

It is important to realize that work zones are *never* uniformly shaped circles and rectangles. Rooms, hallways, buildings, roads, fences, streams, and other physical structures always make establishing work zones difficult. When establishing work zones, maximum use should be made of physical items. "Thirty feet" from the doorway is a meaningless expression in an emergency. Traffic cones, colored barricade tape, chairs laying on their sides, curbs—virtually any physical object—should be used to establish the work-zone boundaries.

Air Monitoring

When hazardous or toxic vapors are a concern at a spill or release site, the use of air-monitoring instruments is necessary to ensure the safety of both on-site and off-site personnel. To adequately sample the air at the site of a spill or release, air-monitoring instruments should be placed at various locations throughout the work site. In addition to semipermanent air samplers, area monitoring stations may also include direct-reading instruments (DRIs), such as photo ionization and flame ionization detectors, which are equipped with recorders and operated as continuous air monitors. Area monitoring stations should be placed in the following locations:

- ***Upwind.*** Many hazardous incidents occur near manufacturing facilities or highways that generate air pollutants. Air must be monitored upwind of the site, and wherever there are other potential sources of contaminants, to establish background levels of air contaminants.
- ***Support or Cold Zone.*** Air must be monitored near the command post or other support facilities to ensure that they are maintained in a clean area.
- ***Contamination Reduction or Warm Zone.*** Air should be monitored along the contamination control line to ensure that personnel are properly protected and the on-site workers are not removing their protective gear in a contaminated area.
- ***Exclusion or Hot Zone.*** The exclusion zone presents the greatest risk of exposure to chemicals and requires the most air sampling. The location of an air-monitoring station should be based upon the hot spots or source areas detected by DRIs, types of substances present, and potential for airborne contaminants.
- ***Fence Line/Downwind.*** Air-monitoring stations should be placed downwind from the site to determine whether any air contaminants are migrating from the site. If there are indications of airborne hazards in populated areas, additional monitors should be placed downwind.
- ***Periodic Monitoring.*** Site conditions and atmospheric chemical conditions may change following the initial characterization. Periodic monitoring should be conducted when the possibility of a dangerous condition has developed or when there is reason to believe that exposures may have risen above PELs since prior monitoring was conducted. The possibility that exposures have risen should be seriously considered when any of the following occurs:
    1. work begins on a different portion of the site
    2. different contaminants are being handled
    3. a markedly different type of operation is initiated (e.g., drum opening, as opposed to exploratory well drilling)
    4. workers are handling leaking drums or working in areas with obvious liquid contamination (e.g., a spill or lagoon)

Personnel Monitoring

The selective monitoring of any high-risk workers (i.e., those who are closest to the source of contaminant generation) is required by 29CFR 1910.120(h). Because occupational exposures are linked closely with active material handling, personal air monitoring is not necessary until site operations have begun. If any employee is exposed to concentrations over PELs, monitoring must continue to ensure the safety of all employees likely to be exposed to concentrations above those limits.

Meteorological Considerations

As an integral part of any air-monitoring plan, data concerning wind speed and direction, temperature, barometric pressure, and humidity, or a combination of these, are needed for selecting air-sampling locations, calculating air dispersion, calibrating instruments, and determining population at risk of exposure from airborne contaminants.

Control and Clean Up

Spill Containment

Containment is the process of stopping a release or preventing its spread through mechanical means without adding chemical or biological agents. Containment methods may include patching and plugging the leaking container; building dikes, berms, or dams; reorientation of the leaking container; overpack drums; portable collection vessels; or others, as appropriate.

Containment devices or substitute containers may be useful in stopping a leak. Be sure the containment device is chemically compatible with the leaking substance. Build dikes, berms, or dams, using earth or sand. A container such as a plastic swimming pool or inflatable raft may be useful. Dig a pit or trench to stop the slow flow of liquids. Use sorbents to slow or stop the flow of material. Placing the leaking container in a larger container (overpack) and filling any space with absorbent materials is an effective means of containment.

Portable collection vessels are usually containers of a size that can be easily transported to the spill site. These may be used to catch the substance as it spills out. This method is often an interim measure used while the leak is being patched. Containment should be the first response considered when a spill occurs because it provides the following advantages:

- minimizes damage to the environment
- allows for on-site clean up
- prevents spilled material from flowing into the waterways or entering into sewers, streams, and subsurface water supplies

Sorbents

Sorbents are materials that physically remove liquid chemicals from surfaces (including the surface of other liquids, such as water). Generally, synthetic sorbents *adsorb* liquids, and natural sorbents *absorb* them. Absorption is the process of taking up a hazardous liquid material. Adsorption is the process in which materials adhere to the surface. Sorbents may be used to slow or stop the flow of material and are often also used as clean-up tools.

Patching and Plugging

If possible, attempt to patch or plug the leak to prevent further releases from occurring during the clean up. The degree of difficulty involved in patching or plugging a leaking container depends on the hazards of the substances involved and the size and location of the leak. For smaller containers, turn it so the leak is on top, then patch or plug with any suitable, chemically compatible material, such as wood plugs or golf tees, pieces of rubber (e.g., patches made from inner tubes), pieces of thin scrap metal, or commercially available kits and devices. Sometimes materials may be solidified or frozen to stop a leak. It may be possible to create an internal patch or barrier with matting or other material. Through proper planning, a plug and patch kit should be available and easily accessible.

Forklift Punctures

Because drums are heavy, they are frequently handled by forklifts. Consequently, many incidents are caused by the forks puncturing the drum about five inches from the bottom. If this occurs, the forklift should be withdrawn from the hole and the drum rotated so the hole is above the product level. The following sequence may be used to patch forklift or other holes:

- Use a wire brush to roughen the area over the hole, removing all paint down to bare metal. Be careful to consider flammability before creating friction and possibly sparks.
- Drive a wooden wedge into the hole with a hammer. Do not drive the wedge completely inside the drum. If lead wool is available, it

should be packed around the wedge to afford a tight seal. Cut the wedge flush with the drum.

- Put aluminum tape over the wedge.
- Put epoxy over the tape and smooth the surface even with the drum.
- Place the drum in a DOT specification overpack "salvage drum" before transporting.

Compressed Gases

Preparing for an emergency involving compressed gases is not possible without familiarity of the properties of the gases on site. After the hazards are identified, develop an emergency response plan that includes, at the minimum, procedures for managing leaks, first aid, and fire prevention. Positive-pressure SCBAs, PPE, fire extinguishers, and other emergency equipment should be readily available for use by trained personnel.

Fires

First, evacuate all personnel who are not actively involved in fire fighting. If a fire has started that is being fed by a flammable oxidizing gas, turn off the supply of gas *only* if it is safe to do so. If a flammable gas fire is extinguished when the valve is still open, explosive mixtures of flammable gas and air may be formed. Never enter an enclosed area unless it has been adequately ventilated and checked with an air monitor.

Once the fire is out, cool the cylinders and surrounding area with water spray (or other material, as indicated on the MSDS). Indiscriminate use of water on fires involving cryogenic liquids can produce icy surfaces. If the fire is coming from the cylinder, it is often best to let it burn itself out. Again, know the chemical and physical properties of the gases on site. Never put a cylinder that has been involved in a fire back in service.

Leaks

Do not attempt to control or repair a leak without the proper equipment and training. Never attempt to manage a leak without knowing the chemical and physical properties of the gas.

First, check the valve; it may not be fully closed. For flammable, inert, and oxidizing gases, notify the appropriate response personnel. Move the cylinder to an isolated area with adequate ventilation. Post warning signs that describe the hazard(s). For corrosive and toxic gases, notify the appropriate response personnel. Don the proper PPE and move the cylinder to an isolated area with adequate ventilation. If possible, direct the gas into an appropriate chemical neutralizer, such as a plastic drum filled with lime or a caustic soda solution. Post warning signs that describe the hazard(s).

Treatment

Depending on the type and amount of material released, one or more treatment or clean-up methods may be available. Spilled or released materials may be treated by chemical, biological, or physical means. Many times, acids and bases can be neutralized (chemical treatment) to make clean up safer and easier and to lessen disposal costs. Oxidation or reduction reactions are another example of chemical treatment. Biological treatment methods may include aerobic or anaerobic degradation, the use of specific fungi or bacteria, the use of abiotic technologies, and others. Coagulation, air stripping, clarification, and burning are examples of physical treatment methods.

Decontamination

Decontamination is the process of removing or neutralizing contaminants that have accumulated on personnel, PPE, tools, instruments, samples, vehicles, and all other equipment and supplies used on site. Proper decontamination protects all site personnel by minimizing the transfer of hazardous substances into clean areas, and it protects the community as a whole by preventing the transportation of contaminants from the site.

Everything—all personnel, clothing, equipment, samples, and so on—leaving the contaminated area of a site must be decontaminated to remove any contaminants that may have adhered to them. Decontamination methods either physically remove any contaminants, inactivate them, or remove contaminants by a combination of both physical and chemical means. Many factors, including availability, ease of use, site resources, and cost, influence the selection of decontamination equipment and methods. To be safe and effective, ensure that the selected decontamination methods are effective for the type of contamination present and that the decontamination methods do not pose additional health or safety hazards.

The best way to minimize the amount of necessary decontamination is to work as cleanly as possible. Here are seven ways to *work clean*:

- Minimize contact with contamination—do not walk through puddles, do not touch obviously contaminated surfaces.
- Use remote tools and equipment as much as possible. Be careful that you are not just contaminating equipment instead of people.
- Protect tools and equipment as much as possible by bagging or wrapping in disposable plastic.
- Wear disposable outer gloves, boot covers, head gear, and suits that are relatively quick and easy to change.
- Cover tools and equipment with strippable coatings that can easily be removed, taking any contamination with them.
- Contain the contamination—use overpacks, plastic sheeting, barrier foams, or thin layers of clean soil to cover contaminated ground.
- Whenever possible, use the least hazardous material/method when working (e.g., use water-based solvents; use a household neutralizer, such as vinegar, instead of a stronger acid).

Contaminants may be found on the surface of personal protective or other equipment or may have permeated the material. Surface contaminants are often easy to see and remove, but contaminants that have permeated a material are very often extremely difficult or impossible to detect and remove. Contaminants that have permeated a material such as gloves or coveralls, and remain undetected, can cause an unexpected, potentially serious exposure when the contaminant reaches the skin. The extent of permeation is determined by the following:

- ***Contact time.*** The longer the contact time, the greater the probability and extent of permeation. Minimizing contaminant contact time is one of the most important objectives of a decontamination program.
- ***Concentration.*** As concentrations of contaminants increase, the potential for permeation increases. One way to minimize this problem is to reduce worker contact time in areas of high contaminant concentration.
- ***Temperature.*** Generally, the permeation rate increases as temperatures increase.
- ***Physical state of contaminants.*** In general, gases, mists, vapors, and low-viscosity liquids tend to permeate more quickly and easily than high-viscosity liquids or solids, just as coffee (low viscosity) permeates your shirt faster than fudge sauce (high viscosity).
- ***Molecule and pore space size.*** As the size of the contaminant molecules decreases, the rate of permeation increases. Also, as the pore space of the material increases, the rate of permeation increases. Because flour has a relatively small particle size, it will pass easily through a flour sifter, but rice would not go through the same sifter as readily, if at all. But if you increase the size of the holes by using a spaghetti strainer, the rice will pass through much more easily.

Decontamination Plan

A decontamination plan should be developed and decontamination equipment should be staged before personnel enter areas where the potential for exposure exists. The decontamination plan should include at least the following information regarding:

- the types, amounts, and concentrations of expected contaminants
- ways to protect clean areas and prevent the spread of contamination both on and off site
- routine and emergency decontamination procedures, including personnel and equipment needed, the number and layout of decontamination stations, and methods that minimize personnel (both workers and decon personnel)

contact with hazardous substances during removal of PPE
- methods of disposal of contaminated clothing, equipment, and wash/rinse solutions

Decontamination Methods

Physical Removal. Removal of particles, vapors, and volatile liquids often may be accomplished by brushing, scrubbing, rinsing, wiping, or evaporating. Other physical removal methods, such as the use of pressurized air or steam jets, can spread contamination and cause injury and are generally not recommended, except under special circumstances.

Contaminants such as resins, adhesives, and other sticky materials are often more difficult to remove. Try scraping, brushing, or wiping. Some adhesive materials are easier to remove when frozen or melted. If the material is highly viscous, it may help to absorb or adsorb it into or onto a chemically compatible material before attempting removal.

Chemical Removal. After removing any gross contamination, follow with a wash and/or rinse, using an appropriate cleaning solution. Always use the least hazardous cleaner or solvent that will accomplish the task. In some cases, this may be merely ordinary household soap or detergent and water. Be sure the cleaning solvent is chemically compatible with the item being cleaned. Be especially careful when cleaning PPE because it can be damaged or destroyed by the use of an incompatible cleaning solvent.

Emergency Decontamination. It is essential to establish and train personnel on emergency decontamination procedures, including methods which will be used to protect emergency aid providers. Whenever possible, delay medical treatment until decontamination has been performed; otherwise, emergency aid providers may become contaminated, which could result in their being unable to perform their duties and result in more victims. In extreme situations where immediate medical treatment is necessary to save a life, delay decontamination until the victim has stabilized as long as it is safe for emergency aid providers to do so (NIOSH, 1985.) Never jeopardize the lives of several people unless absolutely necessary.

Disposable PPE. In order to save time, consider the use of disposable PPE. In this system, all outer wear (boot covers, gloves, suits) is cut or rolled away from personnel while going through the decontamination process. The used, disposable PPE is packed in DOT-authorized containers for transportation and disposal, generally as an RCRA-regulated hazardous waste. While this process consumes more PPE, total cost in terms of manpower for the decontamination system, containment structures for decontamination fluids, laboratory testing, and transportation and treatment of contaminated wash and rinse waters is often considerably more.

Disposal

During the early stages of a spill response, three planning functions should occur simultaneously. Once the spilled materials are established, each of these functions should ensue:

1. Planning tactics to be used during the spill response should be developed. What are the best procedures and tools to be used to stop the release and control the released product?
2. Planning should begin on the type of personal protective equipment to be used and the material(s) that the equipment is made from. What level of protection is required by the response workers?
3. Planning should begin on how to manage—package, transport, and recycle or dispose of—the released material(s) and the sorbents or decontamination products.

The Resource Conservation and Recovery Act (RCRA) regulates the management of all hazardous wastes. There are three broad options under RCRA—storage, treatment, or disposal. Storage of a hazardous waste implies that the waste will be shipped at some future date. This is generally not a viable option for materials left after a spill response.

Treatment, at its simplest level, means the waste is going to be changed into a less hazardous or a nonhazardous material. One common form of treatment is wastewater treatment. If this is the planned waste disposal technique, keeping all spilled liquids in a liquid form, and not solidifying them, is the best tactic to be used. Planning on using pumps to transfer spilled material(s) to transportation containers (drums, vacuum trucks, tank trailers) will produce the desired results with the least handling and minimize risks to workers. If the treatment technique used will be incineration, keeping spilled liquids in a liquid form or adsorbing them on combustible sorbents will result in lower disposal costs. Because of air emission standards on hazardous waste incinerators some materials, such as mercury-containing wastes, must be packaged in relatively small containers. Planning, before the response begins, to place these free or solidified liquids in a container size accepted by incinerators will minimize repackaging after initial containment. Other forms of treatment, such as chemical oxidation, may be possible with either liquid or solid wastes. Again, planning for this option before the spill response begins will result in less waste-handling, minimizing risk to workers and lowering disposal costs.

The third option for hazardous waste management is land-based disposal, either land farming or land filling. Land farming is generally not a viable option for spill residues. Land filling hazardous wastes that have been solidified with nonbiodegradable sorbents is generally more acceptable than land filling wastes solidified with biodegradable materials. Because of land disposal restrictions (LDRs) (also called land bans), hazardous waste may require some type of treatment prior to land filling. As mentioned earlier, knowing the most effective and efficient way to manage the wastes generated by a spill response is vital for preparing response workers to conduct specific procedures and use specific types and sizes of containers. Failing to plan for disposal of spill residues often results in repackaging the waste, which can increase worker exposure and risk. Failing to plan for disposal may result in higher waste packaging, transportation, and management costs.

Transportation Spills and Releases

According to the U.S. Department of Transportation, there are more than 800,000 hazardous material shipments daily in the United States, of which about 315,000 are petroleum products. On the average, more than 3 billion tons of hazardous materials are shipped each year. In terms of the number of shipments, the vast majority are by truck. In any given year, with the exception of catastrophic air and rail disasters, truck incidents involving hazardous materials usually result in more deaths, injuries, and financial losses than all other modes of transportation combined.

The DOT's definition of *transport* and *transportation* is the movement of property and the loading, unloading, or storage incidental to that movement. It is clear, then, that transportation incidents happen at times other than when hazardous materials are actually being conveyed over the roadways. Improper loading, unloading, or transloading account for many transportation-related spills and releases of hazardous material. Examples of improper loading or unloading are dropped packages, loading incompatible materials together, incorrect packaging, punctured packages, improper bracing or blocking of the load, and so on. An example of *transloading* is transferring a hazardous material from a bulk packaging to a nonbulk packaging for the purpose of continuing the movement of the hazardous material in commerce. Since loading and unloading are literally in the hands of people, human error is most often the cause of these incidents. Luckily, people also have the ability to help prevent these types of incidents by ensuring that hazardous materials are properly loaded, segregated, and braced; vehicles are in sound working condition; and that drivers and equipment operators have the appropriate level of knowledge, skills, and experience to safely manage the load.

Operator Emergency Response Capabilities

The outcome of any hazardous material transportation incident is based, to a greater or lesser extent, depending on the circumstances, on the capabilities of the driver or equipment operator. In order to safely and successfully respond to a transportation incident, drivers and equipment operators must have adequate training, equipment, and other resources necessary to manage the spill or release.

DOT Training Requirements. Anyone who loads, unloads, handles, or otherwise prepares hazardous materials for transportation; operates a motor vehicle that transports hazardous materials in commerce; is responsible for the transportation safety of hazardous materials in commerce; or whose duties directly affect the safety of hazardous material transportation, is required to meet the DOT minimum training requirements found in 49 CFR 172.704. Motor vehicle operators must also comply with the training requirements of 177.816. Additionally, individual states may impose more stringent driver training requirements on those who live in that state as long as the requirements do not conflict with DOT training requirements.

DOT training includes four general areas: general awareness, specific functions, safety, and security awareness training. General awareness training familiarizes employees with DOT's training requirements and ensures that they are able to recognize and identify hazardous materials and know what measures to take to protect themselves from those hazards.

Function-specific training is just that: employees must be trained in their specific job functions. As an alternative, employees may be provided with mode-specific training, such as that required by the International Maritime Dangerous Goods (IMDG) Code (IMO, 2006) or the International Civil Aviation Organization (ICAO) (www.icao.int) Technical Instructions, as long as the training addresses the requirements of 49 CFR 171.12 (Import and Export Shipments) and 171.11 (Use of ICAO Technical Instructions).

Training may be provided by qualified in-house personnel or by outside companies or contractors. Many trade organizations, such as the American Petroleum Institute (www.api.org), the Association of Oil Pipelines (www.aopl.org), the American Chemical Society (www.acs.org), International Air Transport Association (www.iata.org), and International Institute of Ammonia Refrigeration (www.iiar.org) offer training programs or publications.

Equipment. The amount and type of available spill response equipment should be selected on the basis of the quantity, size, and type of container(s) being transported, the hazards posed by the materials, the training and experience level of the operator, and the mode of transportation. It is of little value in an emergency to include equipment the operator does not know how to properly and safely use or that is inappropriate for the potential spill or release.

The following list contains equipment and supplies that are useful for response to various types and sizes of transportation spills and releases. The first several items can be useful in nearly all transportation spill/release scenarios; the remaining items may be more useful for management of specific types and sizes of spills.

- personal protective equipment, including chemical-resistant and/or fire-resistant outer garments, gloves, boots, respiratory protection, safety glasses/goggles, and other chemical-specific equipment, as necessary
- first-aid kit
- reflective traffic vests
- fire extinguishers
- leak sealing/patching/plugging kit
- sorbent pads, rolls, or boom
- trash bags, rags and paper towels
- traffic cones, reflective warning devices
- caution tape
- communication devices such as cellular telephones, radios, and so on
- shovels, picks, rakes, brooms, squeegees, and so on
- flashlights or portable lights
- tape: duct and electrical tape have many potential uses at a spill scene
- camera, binoculars
- reference materials, such as material safety data sheets, DOT's *Emergency Response Guidebook*, and others, as applicable to the material(s)
- clean water, brushes, soap, and buckets for decontaminating small tools and equipment
- hand tools such as hammers, crescent and pipe wrenches, bolt cutters, pliers, saws, socket sets, drills, bung wrenches, utility knives, chisels, screwdrivers, vice grips, crow bars
- combustible gas indicator (or other air-monitoring instrument depending on the load) with spare batteries
- fall protection harness

- disinfectant, spray bottles, and biohazard bags
- hand and/or transfer pumps with any hoses, clamps, or necessary fittings
- spark-proof tools
- grounding cables
- dome clamps, hatch cones, valves, camlock adapters, and other specialized equipment and fittings
- plastic or metal pails
- rope
- overpack and salvage drums
- ladder

Other Resources. In some cases, other resources may be needed that are beyond the scope of what the driver or local fire or hazmat team can provide. Some spills or releases require specialized equipment such as cranes, vacuum trucks, compressed gas cylinder overpacks, specialized fire-extinguishing media, specialized valves, or leak-sealing equipment. For large spills and releases, it is likely that outside, contracted help will be needed. Some spills and releases require assistance from highly trained and specialized management teams. Are these resources available to the driver or operator? Does the driver or operator have a list with telephone numbers and points of contact that are available at various points along the route? Does the driver or operator have the authority to contract for emergency assistance? If not, can he or she reach the person with the appropriate authority at all times? Does the driver/operator have the authority to make statements or answer questions from the media? If not, to whom shall he or she refer them?

Driver/Operator Response Actions

If a spill or release of hazardous materials occurs during transport, a driver or operator must perform several tasks within the limitations of his or her training, experience, available equipment, and other resources. It is extremely important that drivers know and understand their personal limits in terms of response capabilities and the limitations of their equipment. Drivers and operators should only attempt control, containment, and other emergency spill response activities that they are fully trained and equipped to manage.

Begin the response action by analyzing the incident and planning the initial response, if it is safe to do so; otherwise, evacuate, call for help, then secure the scene to ensure that others are not injured. When evaluating the situation and gathering pertinent information, note product identification (chemical name), physical and health hazards associated with the product(s), type of container damage (e.g., puncture, crush, leak), extent of the spill or release (e.g., container size and type and the quantity of release), whether the spill or release is complete or ongoing, and whether there are factors that could change the nature or severity of the incident (e.g., the potential for fire, explosion, or the commingling of products).

If outside assistance is needed, notify local authorities, the owner, or other responsible party, and if applicable, the spill contractor or other response organizations. Provide information about the nature of the emergency, including location, product(s) involved, type of vehicle (if pertinent), approximate quantity of spilled or released material, any injuries, any special hazards (e.g., water reactive or radioactive), and any other relevant information.

If possible, provide responders with a method of contact, such as the driver's cellular telephone number or the availability of a citizen's band (CB) or other radio, to be used in the event responders need to contact the driver, which might be the case if the responders are delayed or have a difficult time finding the location of the spill or release.

For bulk containers, determine the safest method to off-load the product and where to position a vacuum or tank truck that will receive the off-loaded product. Possible bulk product removal methods include removal through vapor recovery lines, external or internal valves, unloading lines, or through the dome or hatch covers. Each method has both advantages and disadvantages, so this issue should be preplanned.

Next, secure the scene to ensure that other persons or vehicles are protected from inadvertently entering the area. Equipment and measures to secure the scene may include reflective warning devices, flares (if fire is not a potential hazard), barrier tape, traffic cones, signs, verbal warnings to bystanders or those in nearby dwellings, and so on. If fire is a hazard, turn off the vehicle and shut down other vehicle electrical systems (if so equipped), and remove all other possible sources of ignition.

Begin spill or release mitigation by donning the proper personal protective equipment. If relevant to the spill or release, set up air-monitoring instruments and a fire watch. For rail and tank cars carrying flammable materials, perform bonding and grounding to prevent buildup of static electricity. Perform spill or release control and/or containment procedures, which may include the following procedures, or others, in accordance with the company's spill response plan and procedures:

- Rotate the damaged container so the leak is at the top.
- Turn the container upright.
- Close valves and shut off all pumps.
- Seal storm sewers; dig containment ditches or construct earthen dikes; deploy sorbent pads, socks, or boom.
- Patch or seal leaks or holes.

It cannot be stressed enough that drivers and operators must recognize the limitations of themselves and their equipment. They must be able to recognize the need for more or advanced levels of personal protective and other equipment and the need for more response personnel or for those who are capable of managing more complex incidents. If drivers and operators do not recognize their limitations, it is very possible someone will be injured or, in the case of large or extremely hazardous substance releases, that the spill or release could escalate to the point of being catastrophic.

Incident Termination

When the emergency has passed and all hazardous materials are contained, contaminated equipment and supplies must be decontaminated. This may be accomplished at the scene if the driver/operator has the necessary supplies. If the necessary supplies are not available, contaminated items may be placed in drums or sealed in bags for later decontamination. If these items are contaminated with a hazardous waste, as defined by RCRA regulations, the wash and rinse water from decontamination must be managed as hazardous waste along with the other hazardous waste produced at the scene.

The last step of an incident close-out is to file all required reports. These may include reports to the responsible party (DOT, state agencies, and others), depending on the type, quantity, and location of the spill or release. Refer to the "Federal Assets and Information Sources" section for more information on notifications and reporting.

ABBREVIATIONS

ATSDR	Agency for Toxic Substances and Disease Registry
BLEVE	Boiling Liquid–Expanding Vapor Explosion
CAER	Community Awareness and Emergency Response
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
DOT	Department of Transportation
EPA	Environmental Protection Agency
Fl. P.	flash point
HASP	health and safety plan
HCS	hazard communication standard
HAZWOPER	hazardous waste operations and emergency response
HMT–USA	Hazardous Materials Transportation–Uniform Safety Act
IP	ionization potential
ISO	International Standards Organization
LC_{50}	lethal concentration 50%
LD_{50}	lethal dose 50%
LEL	lower explosive limit
LEPC	local emergency planning committee
LFL	lower flammable limit
MSDS	Material Safety Data Sheet
NFPA	National Fire Protection Association
NRT	National Response Team
OPA 90	Oil Pollution Act of 1990
OSHA	Occupational Safety and Health Administration (U.S. Department of Labor)
PPE	personal protective equipment
PEL	permissible exposure limit
PHMSA	Pipeline and Hazardous Materials Safety Administration (U.S. Department of Transportation)
PID	photo ionization detector
RCRA	Resource Conservation and Recovery Act
RSPA	Research and Special Projects Administra tion (U.S. Department of Transportation) (now part of PHMSA)

SARA	Superfund Amendments and Reauthorization Act
STEL	short-term exposure limit
Sp. Gr.	specific gravity
TLV	threshold limit value
TWA	time-weighted average
UEL	upper explosive limit
UFL	upper flammable limit
VD	vapor density
VP	vapor pressure

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