

The First Responder's Field Guide to **Hazmat & Terrorism** Emergency Response

(2023 Edition)



Jill Meryl Levy
Firebelle Productions

Based on Nationally Recognized Standards and Practices
for Responding to Hazmat Incidents and Terrorist Events

The First Responder's Field Guide to Hazmat & Terrorism Emergency Response

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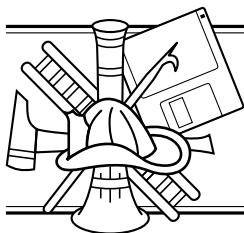
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Table of Contents

Subject	Page
How to Use This Book	iii
Foreword	x
Preface	xii
Acknowledgments	xiv
Introduction and Purpose	xxi
Acronyms and Abbreviations	xxiv
Disclaimer	xxx
Chapter 1 - Quick Reference Guide	1-1
Awareness Level Personnel	1-3
Operations Level Responders	1-4
EMS Responders (BLS and ALS)	1-7
Incident Commander	1-9
Chapter 2 - Recognizing and Responding to a Hazmat/WMD Incident	2-1
How to Use This Chapter	2-3
Be Prepared	2-4
Recognize the Presence of Hazardous Materials	2-5
Call for Trained Personnel	2-6
Make a Safe Approach	2-7
Lay a Safe Foundation	2-10
Report on Conditions	2-11
Assume Command	2-12
Isolate and Deny Entry	2-20
Initiate the Notification Process	2-22
Size Up the Incident	2-24
Collect Hazard Information	2-27
Predict the Behavior of a Material and Its Container	2-29
Estimate the Potential Outcome	2-31
Plan Your Initial Response	2-32
Implement the Planned Response	2-44
Wear Appropriate PPE (Personal Protective Equipment)	2-47
Implement Protective Actions	2-55
Perform Decon as Appropriate	2-57
Evaluate Your Progress	2-61
Facilitate Cleanup and Disposal	2-62
Terminate the Incident	2-63
Document the Incident	2-65

Table of Contents (continued)

Chapter 3 - Labels, Placards, and Other Marking Systems	3-1
Placards and Labels	3-3
Table 1 and Table 2 Commodities	3-7
Class 1 - Explosives (and Blasting Agents)	3-8
Class 2 - Gases	3-9
Class 3 - Flammable and Combustible Liquids	3-11
Class 4 - Flammable Solids, Spontaneously Combustible Materials, and Dangerous When Wet Materials	3-13
Class 5 - Oxidizers and Organic Peroxides	3-14
Class 6 - Poisonous and Infectious Substances	3-15
Class 7 - Radioactive Materials	3-16
Class 8 - Corrosive Materials	3-17
Class 9 - Miscellaneous Hazardous Materials	3-18
Limited and Excepted Quantities	3-19
Materials of Trade (MOTs)	3-20
International Placards and Labels	3-21
UN Portable (Intermodal) Tank Hazard Identification Codes	3-22
NFPA 704 Marking System	3-24
Hazardous Materials Identification System (HMIS®)	3-29
Military Markings	3-32
Other Marking Systems	3-33
Globally Harmonized System (GHS)	3-36
Urban Search & Rescue (US&R) Marking System	3-40
Chapter 4 - Container Recognition	4-1
Containers and Packages	4-3
Nonbulk Packaging	4-5
Bulk Packaging	4-13
UN Portable (Intermodal) Tanks	4-16
Cargo Tanks	4-22
Rail Cars	4-33
Facility Containers	4-45
Other Large "Vessels"	4-55

Table of Contents (continued)

Chapter 5 - Assessing the Hazards	5-1
How Hazardous Materials and WMDs Cause Harm	5-3
Carcinogens, Mutagens, and Teratogens	5-8
Toxicology: Exposure Potential	5-9
Toxicity and Risk	5-12
Toxicological Terms and Exposure Values	5-13
Workplace Environmental Exposure Limits (WEEL)	5-19
Exposure Values Compared	5-21
Properties of Flammable Liquids	5-23
Tools for Comparing Three Primary Threats	5-29
Chemical and Physical Change	5-34
Other Chemical and Physical Properties	5-39
Atmospheric Monitoring	5-48
High-Risk Situations	5-51
Illicit Laboratories	5-52
Hazmat Triage	5-58
Chapter 6 - Medical Management of Hazmat Exposures	6-1
Secondary Contamination	6-3
Patient Decontamination	6-10
Triage	6-16
Common Signs and Symptoms of Hazmat Exposure	6-21
EMS Treatment Protocols	6-26
Coordination with Other Medical Providers	6-30
Handling the Dead	6-31
EMS Equipment and Supplies	6-32
Medical Support for Hazmat Response Personnel	6-33
Heat and Cold Emergencies	6-35
Chapter 7 - Introduction to Terrorism	7-1
What Is a Terrorist Event?	7-3
Accidental Event or Terrorist Attack?	7-4
Distinguishing Between Chemical and Biological Agents	7-6
Special Strategic and Tactical Considerations	7-8
National Terrorism Advisory System (NTAS)	7-9

Table of Contents (continued)

Chapter 8 - Explosives Incidents	8-1
Background Information	8-3
Identification of Explosive Materials	8-6
Common Explosive Devices	8-8
Common Explosives	8-11
Common Initiation Devices	8-18
Other Clues / Indicators	8-20
Upon Discovery of an Explosive	8-21
After Detonation of an Explosive	8-23
Chapter 9 - Chemical Warfare Agents	9-1
General Information About Chemical Agents	9-3
Nerve Agents	9-13
Blister Agents (Vesicants)	9-17
Blood Agents	9-22
Choking Agents	9-25
Riot Control Agents (Irritants)	9-28
Chapter 10 - Biological Agents	10-1
General Information About Biological Agents	10-3
White Powder Calls	10-14
Anthrax	10-20
Botulism	10-22
Brucellosis	10-23
Cholera	10-24
E. coli	10-25
Glanders	10-26
Melioidosis	10-27
Plague	10-28
Q Fever	10-29
Ricin	10-30
Salmonellosis	10-31
Saxitoxin	10-32
Smallpox	10-33
Staphylococcal Enterotoxin B (SEB)	10-35
Trichothecene Mycotoxins	10-36
Tularemia	10-37
Venezuelan Equine Encephalitis (VEE)	10-38
Viral Hemorrhagic Fevers	10-39

Table of Contents (continued)

Chapter 11 - Nuclear Events	11-1
Basic Radiation Concepts	11-3
Units of Radiation Measurement	11-7
Radiation Exposure Limits	11-9
Time, Distance, and Shielding	11-11
Health Effects	11-16
Decon and Patient Care	11-19
Radiation Labels and Placards	11-20
Monitoring Essentials	11-22
Potential Terrorist Scenarios	11-29
Chapter 12 - Tactical Considerations	12-1
Product Control Options—FRO	12-3
Foam	12-11
Additional Product Control Options	12-15
Technical Decon Methods	12-20
Chapter 13 - Additional Considerations	13-1
Dealing with the Media	13-3
Negligence and Liability	13-6
Guidelines to Minimize Liability	13-7
Pre-Event and Event-Specific Planning	13-8
Evacuation / Shelter Concerns	13-10
Protective Action Messages	13-13
Preservation of Evidence	13-16
Dealing with Children	13-21
Chapter 14 - Resources for Information & Assistance	14-1
List of Resources	14-3
<i>Emergency Response Guidebook (ERG)</i>	14-6
Shipping Papers	14-12
Safety Data Sheets (SDS)	14-13
Mandatory Notification Centers	14-15
Local Emergency Responders	14-16
Communications Services	14-19
Community Resources	14-20
Other Local Resources	14-21
School District Superintendents	14-25

Table of Contents (continued)

Media / PIOs	14-26
Health & Medical Resources	14-27
National Response Center (NRC)	14-34
Department of Homeland Security (DHS)	14-39
Transportation Related Resources	14-40
Defense and Military Resources	14-46
Other State and Federal Resources	14-49
Animal Resources	14-55
Internet Resources	14-59

Chapter 15 - Appendix **15-1**

Bibliography	15-3
Index	15-17
About the Author	15-33

Quick Reference Guide



This chapter is designed to be a quick reference guide to the tasks that should be performed at a hazmat incident or terrorist event. It provides a concise overview of first responder responsibilities based on the competencies in NFPA 470.

Most of the tasks listed are cross-referenced to other pages or chapters in this book that provide additional guidance. However, there are a number of other pages not referenced in this chapter that provide important response information. Take time to familiarize yourself with this book before you need it in an emergency so that you become proficient with it.

Awareness Level Personnel

Awareness level personnel are people who, in the course of their normal duties, could encounter an emergency involving hazardous materials or WMDs. This group includes truck drivers, train crews, maintenance workers, and others who work in facilities where hazardous materials or WMDs are manufactured, used, stored, transported, or could otherwise be released. They are expected to recognize the presence of hazardous materials or WMDs, protect themselves, call for trained personnel, and secure the area.

Perform the Following Tasks Safely

Recognize the presence of hazardous materials/WMD. (*pages 2-4 and 2-5*)

Survey (size up) the incident from a safe spot (upwind, uphill, upstream) to obtain information for emergency responders:

- Product name (*page 2-27*), 4-digit identification number (*page 3-4*), or hazard class. (*chapter 3*)
- Labels, placards, and other marking systems. (*chapter 3*)
- Container shapes. (*chapter 4*)

Collect hazard information from the current edition of the *Emergency Response Guidebook* or other appropriate resources (*pages 2-27, 2-28, and 14-6 to 14-11*)

Initiate appropriate protective actions.

- Establish an initial isolation zone. (*page 2-20*)
- Initiate protective actions per the local emergency response plan, your organization's SOPs, and the current edition of the *Emergency Response Guidebook*. (*pages 2-55 and 2-56*)

Initiate the notification process specified in the local emergency response plan and your organization's SOPs.

- Call for trained personnel. (*page 2-6*)
- Make appropriate notifications and call for additional resources as needed. (*pages 2-22 and 2-23 and chapter 14*)

Your responsibilities may go beyond those listed above. However, any actions you take should be within the scope of your employment and the limits of your training, resources, and capabilities. Above all, do not initiate any actions unless it is safe to do so.

Operations Level Responders

Personnel at the operations level respond to hazardous materials or WMD incidents for the purpose of protecting nearby persons, the environment, or property from the effects of the release. They shall be trained to respond in a defensive fashion to control the release from a safe distance and keep it from spreading.

Anyone tasked to respond to a hazmat or WMD incident during the emergency response phase is viewed as an operations level responder. This level includes fire, rescue, law enforcement, emergency medical services, private industry, and other allied professionals. NFPA 470 makes no distinction between career and volunteer responders; it applies to both.

NFPA 470 should also be interpreted to include personnel tasked to respond during the emergency phase of *any* incident that could reasonably be expected to involve hazardous materials or WMDs. Even when agencies have a policy that their personnel will back out and leave a hazmat incident to a hazmat team, there are many scenarios in which firefighters, law enforcement, EMS personnel, and other emergency responders can find themselves in the hot zone before they recognize that hazardous materials or WMDs are present.

Perform the Following Tasks Safely

Recognize the presence of hazardous materials/WMD. *(pages 2-4 and 2-5)*

Ensure your safety.

- Make a safe approach (from upwind, uphill, upstream). *(pages 2-7 to 2-9)*
- Lay a safe foundation. *(page 2-10)*

Initiate command and control activities.

- Report on conditions. *(page 2-11)*
- Assume initial command and establish a command post in a safe location. *(page 2-12)*
- Isolate the area and deny entry. *(pages 2-20 and 2-21)*
- Initiate the notification process. *(pages 2-22 and 2-23)*

(continued next page)

Operations Level Responders (continued)

Survey (size up) the incident to determine magnitude of the problem in terms of potential outcomes. *(pages 2-24 to 2-26)*

- Determine the following:
 - Materials and containers involved. *(chapters 3 and 4)*
 - Whether hazardous materials have been released.
 - Potential for criminal or terrorist activities (including secondary devices or events). *(pages 7-4 and 7-5)*
 - Surrounding conditions. *(page 2-25)*
- Collect hazard and response information from appropriate resources. *(pages 2-27 to 2-28)*
- Predict the likely behavior of a material and its container. *(pages 2-29 to 2-30 and chapters 3 to 5)*
- Estimate the potential outcome. *(pages 2-31)*
- Look at the big picture. Maintain situational awareness.

Plan an initial response. *(pages 2-32 to 2-43)*

- Develop your plan based on the capabilities and competencies of available personnel and equipment.
- Determine the following:
 - Additional resources needed.
 - Response objectives (strategy). *(page 2-32)*
 - Product control options. *(page 2-33 and chapter 12)*
 - Whether your PPE is appropriate for implementing each defensive option. *(pages 2-47 to 2-54)*
 - Decon needed. *(pages 2-57 to 2-58 and 6-10 to 6-15)*
 - Protective actions needed. *(pages 2-55 to 2-56)*

Implement planned response to favorably change the outcome.

- Be consistent with the local emergency response plan and your organization's SOPs.
- Establish and enforce scene control procedures including:
 - Control zones. *(page 2-21)*
 - Emergency decon. *(pages 2-57 to 2-58 and 6-10 to 6-15)*
 - Communications.
- Initiate the incident command system. *(pages 2-12 to 2-19)*
- Use PPE that is appropriate for the hazards and your level of training. *(pages 2-47 to 2-54)*
- Perform product control measures as appropriate. *(page 2-33 and chapter 12)*
- Preserve evidence if possible. *(pages 13-16 to 13-20)*

(continued next page)

Operations Level Responders (continued)

Evaluate the progress of actions taken to ensure response objectives are being met safely, effectively, and efficiently.

- Evaluate the status of product control measures in accomplishing response objectives. *(page 2-61)*
- Communicate the status of planned response. *(page 2-61)*
- Adjust as necessary.

Document your activities. *(pages 2-65 to 2-66)*

The steps identified above represent the core competencies at the operations level. You may have mission-specific responsibilities that go beyond this. Regardless, any actions you take should be within the scope of your employment and the limits of your training, resources, and capabilities. Above all, do not initiate any actions unless it is safe to do so.

EMS Responders (BLS and ALS)

EMS personnel who respond to hazardous materials or WMD incidents shall be trained to meet the NFPA 470 core competencies for operations level responders. They must also be trained to meet the NFPA 470 competencies for BLS or ALS responders, as applicable.

Perform the Following Tasks Safely

Recognize the presence of hazardous materials/WMD. *(pages 2-4 and 2-5)*

Ensure your safety.

- Make a safe approach (from upwind, uphill, upstream). *(pages 2-7 to 2-9)*
- Lay a safe foundation. *(page 2-10)*
- Report on conditions. *(page 2-11)*
- Isolate the area and deny entry. *(pages 2-20 and 2-21)*

Survey (size up) the incident to determine the risks to responders and patients.

- Determine the following:
 - Whether hazardous materials have been released.
 - Hazards present. *(chapters 3 and 5)*
 - Potential for criminal or terrorist activities (including secondary devices or events). *(pages 7-4 and 7-5)*
 - Number of patients.
 - Risk of secondary contamination and need for body substance isolation procedures. *(pages 6-3 to 6-9)*
 - Need for and effectiveness of patient decon.
- Collect hazard and response information from appropriate resources to determine the nature of the problem and potential health effects of the substances involved.
- Look at the big picture. Maintain situational awareness.

(continued next page)

EMS Responders (BLS and ALS) (continued)

Plan to deliver BLS or ALS care to exposed patients.

- Identify the capabilities of the hospital network to accept exposed patients and perform emergency decon if required.
- Identify the medical components of the communications plan.
- Identify your role (and limitations) per the local emergency response plan and the incident management system.
- If the incident warrants it, identify supplemental medical resources, including those from the strategic national stockpile (SNS) and the metropolitan medical response system (MMRS).

Implement a prehospital treatment plan within your scope of practice.

- Evaluate patients for signs and symptoms of exposure. *(pages 6-21 to 6-25)*
- Determine the appropriate emergency care. *(pages 6-26 to 6-29)*
- Treat the patients.
- Transport patients to medical facilities capable of performing emergency decon (if needed) and best able to treat the specific injuries. *(pages 6-9 and 6-30)*
- Provide medical support for incident response personnel. *(pages 6-33 to 6-34)*
- Request additional medical resources (personnel, equipment and supplies, antidotes, transport units, etc.) as needed.
- Preserve evidence if possible. *(pages 13-16 to 13-20)*
- Participate in the incident debriefing and critique as appropriate. *(pages 2-63 to 2-64)*

Document your activities. *(pages 2-65 to 2-66)*

Incident Commander

The incident commander is the person responsible for all incident activities, including developing strategies and tactics, ordering resources, and releasing resources. When a unified command has been established for multiagency or multijurisdictional incidents, the lead persons for each agency collectively manage the incident.

Incident commanders are expected to meet all competencies at the awareness level, all core competencies at the operations level, and all competencies at the incident commander level outlined in NFPA 470. Incident commanders are also expected to receive any additional training necessary to meet applicable governmental regulations and the specific needs of the jurisdiction.

Perform the Following Tasks Safely

Survey (size up) the incident to determine the magnitude of the problem and potential outcomes.

- Collect and interpret hazard and response information from appropriate resources. *(pages 2-27 to 2-28, chapter 5)*
- Estimate the potential outcome. *(page 2-29 to 2-31)*
- Assess the potential for criminal or terrorist activities (including secondary devices or events) *(pages 7-4 and 7-5)*
- Look at the big picture. Maintain situational awareness.

Plan the response operations.

- Designate a safety officer. *(pages 2-15 to 2-17)*
- Identify the response objectives (strategy) *(page 2-32)*
- Identify the potential action options (defensive, offensive, and nonintervention) available by response objective. *(pages 2-32 to 2-33)*
- Approve the level of PPE required for a given action option. *(pages 2-47 to 2-54)*
- Develop an incident action plan and site safety plan *(pages 2-32 to 2-43)* that is:
 - Consistent with the local emergency response plan and your organization's SOPs, and
 - Within the capabilities and competencies of available personnel and equipment.

(continued next page)

Incident Commander (continued)

Implement the planned response to favorably change the outcome.

- Implement the incident command system, including procedures for notification and utilization of nonlocal resources. Emergencies should be managed using the Incident Command System (ICS) as defined by the National Incident Management System (NIMS). *(pages 2-12 to 2-19 and page 2-44)*
- Direct resources with expected tasks assignments and on-scene activities.
- Provide management overview, technical review, and logistical support to private and governmental sector personnel.
- Provide a focal point for information transfer to media and local elected officials. *(pages 13-3 to 13-5)*
- Preserve evidence if possible. *(pages 13-16 to 13-20)*

Evaluate the progress of actions taken.

- Evaluate the planned response to ensure response objectives are being met safely, effectively, and efficiently. *(page 2-61)*
- Adjust as necessary.

Terminate the incident.

- Transfer command (control) when appropriate.
- Conduct an incident debriefing. *(page 2-63)*
- Conduct a multiagency critique. *(page 2-64)*
- Document the incident and submit the report to the designated agency. *(pages 2-65 to 2-66)*

Recognizing and Responding to a Hazmat/WMD Incident



This chapter contains general guidelines for responding to a hazmat incident or terrorist event and is based on nationally accepted standards and practices. However, there is no “one size fits all” approach to dealing with these incidents. It will be up to you to accurately size up the incident and adjust accordingly.

These are general guidelines only. All local, state, federal, and jurisdictional laws, regulations, and standard operating procedures (SOPs) take precedence over these guidelines.

How to Use This Chapter

This chapter is designed to be used in conjunction with the Quick Reference Guide in Chapter 1. The Quick Reference Guide provides a concise overview of your responsibilities. This chapter provides more detailed explanations to help you understand those responsibilities.

The Order of Things

The information in this chapter was organized *primarily* for operations level responders. Responsibilities for awareness level personnel, EMS personnel, incident commanders, and safety officers are incorporated where appropriate. Once again, there is no “one size fits all” approach to dealing with hazmat incidents or terrorist events. There are times it may be appropriate to modify the order in which you accomplish the following activities.

<u>Topic</u>	<u>Page</u>
Be Prepared	2-4
Recognize the Presence of Hazardous Materials or WMDs	2-5
Call for Trained Personnel	2-6
Make a Safe Approach	2-7
Lay a Safe Foundation	2-10
Report on Conditions	2-11
Assume Command	2-12
Isolate and Deny Entry	2-20
Initiate the Notification Process	2-22
Size Up the Incident	2-24
Collect Hazard Information	2-27
Predict the Behavior of a Material and Its Container	2-29
Estimate the Potential Outcome	2-31
Plan Your Initial Response	2-32
Implement the Planned Response	2-44
Wear Appropriate PPE (Personal Protective Equipment)	2-47
Implement Protective Actions	2-55
Perform Decon as Appropriate	2-57
Evaluate Your Progress	2-61
Facilitate Cleanup and Disposal	2-62
Terminate the Incident	2-63
Document the Incident	2-65

Make a Safe Approach

Hazmat incidents and terrorist events differ from other emergencies in that they often present a greater potential for harm and they require responders to be trained and equipped to properly deal with the incident.

Guidelines for Making a Safe Approach

- Respond slowly and methodically. Always think safety!
- Approach from upwind, uphill, and upstream.
- Do not drive through spills or clouds.
- Maintain a safe distance, and use binoculars as needed.
- Park vehicles headed away from the scene for a quick escape.
- Avoid blocking other emergency vehicles.
- Be alert for signs of criminal or terrorist activity, including the possibility of secondary events or devices.

Recommended Distances - Outdoor Incidents

If you know the product, use the *Emergency Response Guidebook* (ERG) for recommended safe distances. Remember, however, that the ERG is geared for the initial response phase of an incident (roughly the first thirty minutes). These distances may need to be adjusted as the incident progresses.

If you don't know the product, you can use the distances on the following page, adapted from the "Public Safety" sections of the ERG. Adjust as needed based on wind, rain, topography, fire, etc. If you don't know the hazards of the material, consider its form; anything in gas form or any liquid that appears to have a high vapor pressure (is evaporating rapidly) is potentially more dangerous.

Note: The ERG generally defines a *small* spill as one involving one small package (e.g., up to a 55-gallon drum), a small cylinder, or a small leak from a large package. It defines a *large* spill as a spill from a large package or multiple spills from many small packages. However, one must also consider the chemical and physical hazards associated with the material, as well as environmental conditions that impact the overall risk. A 5-gallon spill of a highly toxic material, for example, may present a far greater risk than a 500-gallon spill of a combustible liquid.

(continued next page)

Make a Safe Approach (continued)

Recommended Distances - Outdoor Incidents (continued)

The distances cited below are extrapolated primarily from information in the ERG.

The following general guidelines are *minimum initial isolation distances* for spills or leaks.

<u>Distance</u>	<u>Hazard Potential</u>
75 feet (25 meters)	low to moderate
150 feet (50 meters)	significant
330 feet (100 meters)	high
1/3 mile (0.5 kilometers)	most explosives

The following *minimum initial downwind evacuation distances* are general guidelines geared for **large spills**. (Distances may be greater for substances highlighted in the ERG yellow or blue sections and listed the green section—Table of Initial Isolation and Protective Action Distances.)

<u>Distance</u>	<u>Hazard Potential</u>
330 feet (100 meters)	moderate
800 to 1000 feet (0.25 to 0.3 kilometers)	significant
1/3 to 1/2 mile (0.5 to 0.8 kilometers)	high

The following *minimum evacuation distances* are general guidelines that apply to **fires**.

- **1000 feet** (0.3 kilometers) - fires involving radioactive materials
- **1/3 to 1 mile** (0.5 to 1.6 kilometers) - fires involving tanks, rail cars, or tank trucks

For **explosive devices**, refer to the Improvised Explosive Device (IED) Safe Stand Off Distance chart in the ERG for recommended distances. (Greater distances may be prudent, depending on the circumstances. Be particularly cautious if there is any possibility that emergency responders may be targeted. Terrorists who gain access to our training materials may build or plant devices to harm us at what we believe to be safe distances.)

Make a Safe Approach (continued)

Recommended Distances - Indoor Incidents

It is more difficult to provide recommended distances for indoor incidents because there are so many variables. The building itself can make it difficult to even see the release and determine the scope of the incident.

You may be able to use the recommended distances listed on the previous page as a starting point. Another guideline that may work, depending on the product and quantity involved, is to keep at least one room or floor between you and the hazardous material. Remember that you still want to be “upwind” and “uphill” from the product, but these terms take on new significance inside a building. It may be unsafe to be on floors above or below the release, depending on the vapor density of the material and pathways between floors (routes a liquid, vapor, or gas may travel). (See pages 5-39 and 5-40 for information on vapor density.) Anticipate that the product may spread via air handling systems, floor drains, etc., and adjust accordingly.

Particularly in buildings that cannot be easily evacuated (e.g., hospitals, nursing facilities, and jails), you may need to control the spread of the product as another way to maintain a safe distance and protect people who might otherwise be threatened by the release. For example, it may be appropriate to shut down air handling systems to avoid circulating gases or vapors to other areas or, conversely, to turn air handling systems to the exhaust mode to ventilate the building. However, this kind of decision requires careful evaluation of the product, the HVAC system, the facility, and the surrounding environment. Consult with facility personnel for information and assistance. Key players may include people from the following departments: Environmental, Health & Safety (EHS); Security; Facilities; Health Services; Shipping & Receiving (or Materials Management); and managers or supervisors from departments that use the hazardous materials.

The “Rule of Thumb” - Outdoors or Indoors

If you're not sure of the appropriate distance, back out and err on the side of safety. Consider, too, the old “rule of thumb.” If you've backed out to the recommended distance but can see the incident beyond your outstretched thumb, you may still be too close.

Lay a Safe Foundation

What happens in the first minutes of an incident significantly affects what happens in the hours that follow. The guidelines below can help you lay the foundation for a safe response. Additional guidelines are provided throughout the book where appropriate.

Safety Concerns Immediately Upon Arrival

- Treat all materials as hazardous until proven otherwise.
- Observe *all* hazards. Most chemicals have multiple hazards associated with them. Other dangers can include traffic, tripping hazards, electrical hazards, sharp objects, or confined spaces.
- Be alert for signs of criminal or terrorist activity, including the possibility of secondary events or devices. Don't touch suspicious items. Call for a hazmat team and/or bomb squad.
- Do not underestimate the hazards at a small incident. Many chemicals are extremely hazardous in very small quantities.
- Keep in mind that wind, rain, topography, and other variables can change the risks and impact your strategy and tactics.
- Have a plan in place before taking action. Anticipate problems and plan accordingly.
- Use the buddy system, and have backup personnel (a rapid intervention crew) standing by as appropriate.
- Isolate the area and deny entry to all unauthorized personnel.
- Give a good report on conditions (description of the problem, size of the hot zone, safe approach routes, safe staging area, etc.) that your dispatcher can relay to other responding units.
- Eliminate ignition sources (e.g., open flames, pilot lights, smoking materials, heated surfaces, electrical sparks, or static electricity) if flammable vapors are suspected and *if you can do so safely*. Keep people out of potentially flammable atmospheres.
- Do not rush to aid patients without adequately assessing the risk, wearing appropriate PPE, and ensuring that some form of emergency decon is in place.
- Decon patients before providing first aid. (Limit emergency care performed during decon activities to gross management of ABCs and immobilizing the cervical spine as needed.)
- Stop any unsafe act immediately. Correct unsafe conditions before resuming activities.
- Do not touch, ingest, or inhale an unknown material.
- Do not eat, drink, or smoke in the incident area. Wash hands thoroughly before eating, drinking, or smoking.
- Prevent unnecessary contamination of clothing and equipment.
- Follow your department SOPs.

Assume Command

National Incident Management System (NIMS) and Incident Command System (ICS)

Emergencies should be managed using the Incident Command System (ICS) as defined by the National Incident Management System (NIMS). Key features of NIMS/ICS include:

- Common terminology
- A modular and scalable organization
- Management by specific measurable objectives
- Reliance on an incident action plan (IAP)
- Establishment and transfer of command
- Chain of command (an orderly line of authority) and unity of command (a designated supervisor for every individual)
- A manageable span of control (three to seven individuals reporting to one position, with a five-to-one ratio being optimum)
- Comprehensive resource management (for personnel, teams, equipment, supplies, and facilities)
- Personnel accountability
- Integrated communications
- A unified command structure
- Information and intelligence management

Duties of the First-Arriving First Responder

As soon as possible, the first-arriving operations level responder should take the following steps.

- Formally assume command.
- Establish a command post at a safe distance upwind, uphill, and upstream from the incident. Make sure the command post is clearly marked and that access is limited to avoid confusion.
- Manage the event until relieved by a higher authority.
- Transfer command, when appropriate, by fully briefing the incoming commander face-to-face with details of the incident and by communicating the transfer of command to other personnel.

If conditions require immediate action (e.g., rescue), it may be appropriate to pass command to the next-arriving unit. If you do so, however, you must clearly communicate your intent to pass command, as well as the conditions you've found on scene and the actions you plan to implement.

Assume Command (continued)

Duties of the Incident Commander

These pages contain some of the duties identified in:

- 29 CFR 1910.120: Hazardous Waste Operations and Emergency Response
- NFPA 470, Hazardous Materials/Weapons of Mass Destruction (WMD) Standard for Responders
- NFPA 1500, Standard on Fire Department Occupational Safety, Health and Wellness Program
- NFPA 1561, Standard on Emergency Services Incident Management System and Command Safety

The incident commander's responsibilities are more comprehensive than those listed below. Many are sprinkled throughout this book. Others are beyond the scope of this book and should be part of the incident command training provided by your employer. While the incident commander has ultimate responsibility for these activities, many require assistance from a trained hazmat team.

- Establish a stationary command post located in or tied to a vehicle, and relay its location to the communications center.
- Provide security for the command post if appropriate.
- Initiate a personnel accountability system. (See page 2-41.)
- Monitor tactical, command, and emergency radio channels.
- Identify, to the extent possible, all hazardous substances or conditions present. Address, as appropriate, site analysis, use of engineering controls, maximum exposure limits, hazardous substance handling procedures, and use of new technologies.
- Evaluate potential harm within the endangered area. Look at the big picture; maintain situational awareness.
- Do a risk-versus-gain analysis. Risking the safety of emergency responders is acceptable only when there's a potential to save other lives.
- Determine response objectives (defensive, offensive, and nonintervention), product control options, and a process for determining potential effectiveness of each option.
- Develop and/or approve the incident action plan (IAP) that is (1) consistent with the local emergency response plan and SOPs and (2) within the capabilities of available personnel, PPE, and control equipment. Make sure the plan is communicated to all incident personnel.

(continued next page)

Assume Command (continued)

Duties of the Incident Commander (continued)

- Limit the number of responders in potentially hazardous areas to those who are actively performing emergency operations.
- Ensure that operations in hazardous areas are performed using the buddy system in groups of two or more.
- Make sure backup personnel (rapid intervention crew) are standing by with equipment ready to provide assistance or rescue.
- Have EMS personnel standing by with medical equipment and transportation capability.
- Ensure that PPE worn is appropriate for the hazards to be encountered.
- Ensure that emergency responders exposed to potential inhalation hazards wear SCBA until it's determined through air monitoring that a decreased level of respiratory protection will not result in hazardous exposures.
- As the incident escalates, divide the incident into tactical-level management components. Assign sufficient supervisory personnel to oversee site operations and ensure safety.
- Designate a safety official who is knowledgeable in the operations being implemented at the site. (The incident commander may also act as safety officer at a minor event.)
- Identify safe operating practices to be followed.
- Maintain an effective span of control (three to seven people reporting to one position, with a five-to-one ratio being optimum).
- Assign a public information officer (PIO or IO), and determine what information is to be provided to the media.
- Coordinate with the EOC if activated.
- Ensure that evidence is properly protected, documented, and collected. (See pages 13-16 to 13-20.)
- Evaluate the effectiveness of the incident action plan (IAP) in accomplishing the objectives. Adjust as required.
- Transfer command, if appropriate, when officers of higher authority arrive or when a new operational period begins.
- Request additional resources as appropriate. (Chapter 14 lists many resources that may be required or helpful.) Provide planning, logistical, and administrative support to those resources.
- Provide for liaison and coordination with other agencies.
- Implement a unified command as appropriate.
- Implement appropriate decontamination procedures.
- Conduct an incident debriefing. (See page 2-63.)
- Document the incident. (See page 2-65 to 2-66.)

Isolate and Deny Entry

Establish an Initial Isolation Zone (Perimeter)

Set up an *initial isolation zone*, or perimeter, to separate people from the problem. This step is also known as *isolate and deny entry*. (Evacuation or sheltering in place may also be necessary. See pages 2-55 and 2-56 for details.) The following are some key points to ensure the effectiveness of your initial isolation zone:

- Direct potentially contaminated people to a safe refuge area for evaluation and decon if needed.
- Direct witnesses who may have important information to remain on scene in a safe location until interviewed and released.
- Establish the initial isolation zone based on the ERG or other reference sources, department SOPs, or the recommended distances on pages 2-7 and 2-8.
- If you are unsure of the appropriate distance, assume the worst and err on the side of safety. It is generally easier to reduce a larger isolation zone than it is to expand a smaller one.
- Make the isolation zone larger on the downwind side. Anticipate wind changes and adjust as needed.
- First isolate areas that are immediately affected. Isolate other nearby locations as appropriate to protect people or to create staging areas for responders and equipment. Don't overlook the air space above the incident or nearby bodies of water that may also need to be isolated.
- Deny entry to all unauthorized personnel. Control the zone(s) and all entry points to limit access to contaminated areas.
- Continue to evaluate the effectiveness of the isolation zone throughout the incident, and adjust as needed.
- Use existing barriers (gates, fences, etc.) whenever possible. They are generally more reliable than barrier tape and traffic cones are. You still need personnel for access control, but you won't tie up as many resources.
- Use law enforcement officers and/or facility personnel as needed to help restrict access.
- Do not use flares if flammable vapors are suspected.

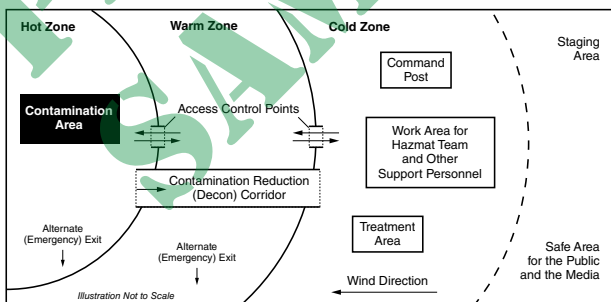
Limit the number of responders at the site, but don't compromise safety. Request enough resources to safely manage the incident. Use the buddy system; don't allow anyone to work alone in a potentially hazardous environment. Have a backup team (rapid intervention crew) standing by.

Isolate and Deny Entry (continued)

Assist in Setting Up Control Zones

A hazmat team will set up *control zones* based on established exposure limits (see pages 5-13 to 5-21) and the results of atmospheric monitoring. This is usually not done by first responders, although they can assist once the appropriate distances are known. The three control zones are as follows:

- **Hot (Exclusion) Zone** - The area immediately around the incident where contamination exists. It should extend far enough to prevent adverse effects from hazardous materials releases to personnel outside the zone. Entry into the hot zone requires the use of proper PPE.
- **Warm (Contamination Reduction) Zone** - The zone where decontamination activities take place. It requires the use of proper PPE once contaminated people or equipment enter the zone.
- **Cold (Support) Zone** - A clean area outside the contamination control line where command and support functions take place. Special PPE is not required in this area (though it's wise to have it handy in case of an emergency or a sudden wind shift). Note: While it is safe for the public and the media to be in the cold zone, they should be kept far enough away from command and support functions that they don't interfere.



Sample Control Zone Layout

Specific access control points are used to control movement of people in and out of the zones. However, an alternate exit route should be established for personnel working in these zones in case of a sudden wind shift or an emergency that blocks the primary escape route.

Size Up the Incident

The following is an overview of things to look at when sizing up the incident. Additional information can be found on the pages and/or chapters as indicated. Keep in mind that size-up is an ongoing process that starts when the emergency is first reported and continues throughout the incident.

Know What to Look For

Awareness Level Personnel

Survey (size up) the incident from a safe location to obtain vital information for emergency responders. Look for the following:

- Product name
- Labels, placards, and other markings (*chapter 3*)
- Container shapes and markings that may indicate the presence of hazardous materials (*chapter 4*)
- Signs of criminal or terrorist activities (*chapter 7*)

Operations Level Responders

Analyze (size up) the incident from a safe location to determine the magnitude of the problem in terms of potential outcomes. Look at the big picture. (Maintain situational awareness.) Determine the following:

- Hazardous materials (*chapter 3*) or WMDs (*chapters 8 to 11*) involved, including identity, form (solid, liquid, gas), and amount
- Labels, placards, and other markings (*chapter 3*)
- Containers involved, container markings, and the extent of damage to the containers (*chapter 4*)
- Surrounding conditions (*page 2-25*)
- Signs of criminal or terrorist activities (*chapter 7*) and the possibility of secondary events or devices

Once you have analyzed the incident:

- Collect hazard and response information from appropriate resources (*pages 2-27 and 2-28*)
- Predict the likely behavior of the material and its container (*pages 2-29 and 2-30 and chapters 3 through 5*)
- Estimate the potential outcome (*page 2-31*)

Size Up the Incident (continued)

Know What to Look For (continued)

EMS Personnel

Survey (size up) the incident from a safe location. Look for items listed under the awareness level (*page 2-24*) plus these:

- Risk of injury to patients and response personnel
- Number of patients, their locations, potential injuries, and need for decon
- Environmental factors that may affect patient care (e.g., indoor versus outdoor exposures, weather conditions)
- Medical support needed for responders (*pages 6-33 to 6-34*)
- Risk of secondary contamination and precautions needed to care for patients in the warm zone if applicable (*pages 6-3 to 6-15*)

Pay Attention to Surrounding Conditions

Pay attention to the surrounding conditions that can affect both the risks involved and the way you handle the incident.

- Topography that can affect the flow of liquids, vapors, and gases
- Land use on affected and nearby properties (e.g., schools, hospitals, rail lines, highways, and airports)
- Accessibility for incoming resources
- Weather conditions (e.g., temperature, wind, and rain)
- Rivers, creeks, or other bodies of water threatened
- Public exposure potential (e.g., number of people threatened and high-risk populations)
- Overhead and underground wires and pipelines
- Storm and sewer drains that may need to be protected
- Possible ignition sources (e.g., a lit match, smoking materials, flares, electrical sparks, pilot lights, static electricity, or friction)
- Situations requiring intrinsically safe (nonsparking) equipment
- Building information (floor drains, ventilation ducts, air returns, secondary containment systems, etc.)
- Confined spaces with atmospheric hazards (oxygen-deficient, oxygen-enriched, flammable, explosive, or toxic) and physical hazards (engulfment, falls and slips, electrical, structural, or mechanical)
- Safe refuge areas and emergency escape routes

Size Up the Incident (continued)

Pay Attention to Surrounding Conditions (continued)

Resources for obtaining current and prediction weather conditions can include:

- Weather channel on responder radios (if applicable)
- Weather channel on cable or satellite connections
- Weather apps on computers, smart phones, etc.
- Local airport weather sources
- Local weather phone recordings
- Satellite technology on hazmat units

Determine the Incident Level

Response organizations should develop a “tiered response plan” to ensure the right resources are dispatched based on the potential risks of an incident and the capabilities and limitations of the responders. The ability to correctly assess the incident level will help get those resources mobilized early.

The following are general descriptions for a three-tiered response that can be modified based on the needs and resources in your community.

Level 1 hazmat incidents can generally be controlled by first responders. They are small incidents posing little or no threat to life, the environment, or property. No evacuation is required beyond isolating the immediate area around the container or material.

Level 2 hazmat incidents are beyond the capabilities of first responders. They require the services of a trained hazmat team and may require assistance from other regional, state, or federal resources. These incidents pose a potential threat to life, the environment, or property and may require limited protective actions in the surrounding area.

Level 3 hazmat incidents require a joint response from multiple resources, which may include local, regional, state, and federal agencies plus private industry. These incidents pose a severe threat to life, the environment, and property and may require large-scale protective actions.

Plan Your Initial Response

Before implementing any activity, identify all hazards present, the resources available to deal with the problem, and what exposures can be saved through your efforts. Look at the big picture. (Maintain situational awareness.) Your incident action plan (or site safety plan) is built on that information and becomes a framework for how emergency personnel are going to operate. It also helps the incident commander establish objectives to measure results. Keep in mind that if you fail to plan, you may be planning to fail.

Note: Pages 13-8 and 13-9 contain guidelines to help you ensure that incident action plans (IAPs) contain the required elements.

Response Objectives (Strategy)

By definition, operations level responders are limited to *defensive* actions for the purpose of protecting life, the environment, and property. However, they can have additional competencies that are specific to their response mission, expected tasks, equipment, and training as determined by the authority having jurisdiction. You must decide which objective, or strategy, is most appropriate based on the incident and the resources available to handle it.

Sometimes the best course of action is to do nothing beyond isolate and deny entry. **No action (nonintervention)** may be appropriate in situations where it is unsafe to do anything, the incident poses no risk to life, or there is a lack of adequate resources to safely and effectively deal with the problem.

Defensive actions are conducted to restrict, slow, or redirect the spread of a hazardous material and to keep it as close to the source as is safe and practical.

Offensive actions are those conducted to stop the release. They are usually done by hazardous materials technicians. However, offensive actions may, on occasion, be performed by a first responder. For example, fighting a hazardous materials fire is an offensive operation, though it may or may not be the best course of action, depending on the material involved. Remember, do not undertake any offensive actions unless you have been properly trained, you have the right PPE, and it is safe to do so. Follow your department SOPs.

Plan Your Initial Response (continued)

Product Control Options

If action is needed (as opposed to nonintervention), determine which product control option is most appropriate. Product control options at the first responder level ...

- Are those with limited risk of personal exposure
- Are intended to:
 - Confine or contain a release of a hazmat or WMD or
 - Control a flammable liquid or flammable gas release
- Are within the capabilities and competencies of available responders, tools, equipment, PPE, and resources
- Are in accordance with the policies and procedures of the authority having jurisdiction.

Options at the first responder level generally include the following:

- Absorption and adsorption
- Diking, damming, diversion, and retention
- Dilution
- Remote valve shutoff
- Vapor dispersion
- Vapor suppression (blanketing)

These options fit into two categories: containment (keeping a material in its container) and confinement (keeping a material, once released, in a defined area or location). (More information about product control options can be found in Chapter 12.)

Determine the potential effectiveness of each option you're considering by assessing the following:

- The purpose for your actions
- Potential deaths and injuries (risk versus gain)
- Potential environmental and property damage (risk versus gain)
- Whether the option is within the scope of your training
- Whether your PPE provides adequate protection
- Proper procedures and safety precautions
- Resources required (personnel and equipment)

Note: This book is not designed to provide instructions on how to perform these options. It provides only general guidelines. You must follow your training and your department SOPs.

Plan Your Initial Response (continued)

No-Go Situations

NFPA 470 cites the following as conditions under which personnel would not be allowed into the hot zone. This is not necessarily a complete list, but it is a good starting point. If you *can't* change conditions below, stay out of the hot zone. If you *can* change conditions to make operations safer, it gives you more options.

- Decontamination plan not established or not in place
- Emergency medical services not available
- Backup personnel not available or not in place
- Flammable or explosive atmosphere present
- Oxygen-enriched atmosphere present (23.5% or greater)
- Required PPE not available
- Risk outweighing benefit
- Personnel not properly trained
- Insufficient personnel to perform tasks
- No identified tactical operations can positively influence outcome
- Runaway reaction occurring

Respected instructor Michael Callan teaches the concept of **Safe, Unsafe, or Dangerous**—another tool that you can use to help determine an appropriate response:

- **Safe:** No harmful effects from the chemicals currently exists.
- **Unsafe:** Harmful effects are possible with prolonged exposures. Potential injuries are not life-threatening, because concentration and/or exposure time are limited.
- **Dangerous:** An immediate threat to life and health exists. Deadly, catastrophic events are possible.

The greatest danger exists where there is a potential for an uncontrolled release of energy (explosives, overpressurized tanks, runaway polymerization, etc.). However, topping the list of dangerous situations is the unknown atmosphere, because you can't reliably protect yourself if you don't know the hazards.

Oxygen-enriched and flammable atmospheres are generally more dangerous than toxic atmospheres are, because explosion and fire, if they happen, are an immediate threat; PPE provides only limited protection. In a toxic or oxygen-deficient atmosphere, if you have the proper PPE, there's no immediate threat; air supply normally dictates how long responders can remain in the hot zone.

Plan Your Initial Response (continued)

Specific Equipment and Procedures

- Determine if the available PPE is appropriate.
- Determine if there is a rescue involved and what resources are required to safely accomplish it. (See page 2-36.)
- Determine whether lockout-tagout and/or confined space entry procedures are needed. Request resources as appropriate.
- Identify whether there are multiple patients, whether triage is needed, and how triage will be accomplished.
- Identify decon procedures for patients and responders. Establish a plan to contain contaminated patients. If contaminated patients have already left the scene, alert area hospitals.
- Determine the level of medical care needed.
- Establish a plan to provide medical support (including medical monitoring) for responders.
- Identify potential problems or risks before taking action.
- Establish emergency procedures in case anything goes wrong. Make sure everyone knows where to go and what to do if problems arise. Have appropriate equipment standing by.
- Identify whether criminal or terrorist activities are suspected. If so, identify the potential for secondary events, weapons, and booby traps. Establish security procedures to ensure that only authorized personnel are allowed access to the scene.
- Identify procedures to preserve evidence. This is vital when criminal or terrorist activities are suspected, but can also aid in cost recovery with accidental releases. (Evidence preservation guidelines are included on pages 13-16 to 13-20.)
- Include a communications plan in your incident action plan:
 - Make sure all personnel have reliable radios and are on appropriate channels.
 - Use intrinsically safe radios in potentially flammable atmospheres.
 - Have a backup plan (e.g., hand signals or air horn blasts) in case of an emergency or equipment failure.
 - Request priority cell phones from your local phone companies if radio frequencies become overloaded.
- Determine if atmospheric monitoring is needed and what resources are required to safely accomplish it.
- Determine if protective actions (evacuation or in-place protection) are necessary. If so, determine how to best implement the appropriate protective action and provide instructions to the public. (Sample protective action messages are included on pages 13-13 to 13-15.)

Plan Your Initial Response (continued)

Rescue Considerations

General Questions

Anytime a rescue is involved, it adds a lot of stress to the situation. This page is not intended to answer the question of whether or not you should attempt a rescue, but rather to address some of the key points that must be considered. You must adequately size up the situation and determine if attempting a rescue is in the best interest of all parties. Do a risk-versus-gain analysis. How can you do the most good for the most number of people? Remember to follow your department SOPs.

- Can the patients self-extricate? Can you “rescue” them without entering the hot zone?
- Can you confirm that downed patients are still alive?
- What are the patients’ chances of survival? Is a successful rescue possible, or will this be a body recovery operation?
- How many people need to be rescued?
- How long will it take to effect a rescue?
- What is the degree of risk posed by the material? Consider health, flammability, and reactivity hazards; the form of the product (solid, liquid, or gas); size and location of the release; and any variables that might increase the risk.
- What other hazards are present? Consider *all* aspects of scene safety.
- Is this a confined space? If so, are you properly trained and equipped for confined space operations?
- Could this be a terrorist event with secondary devices designed to injure responders?
- Do you have appropriate PPE?
- Can you perform a rescue without getting directly in the product? If not, can you limit your exposure to areas of your body that are adequately covered by protective clothing?
- Do you have enough first responders with proper training to effect a safe and successful rescue?
- Are you using a buddy system?
- Do you have a backup team (rapid intervention crew) in place?
- How soon can a trained and equipped hazmat team be on scene and ready to perform the rescue?
- Do you have some form of emergency decon in place? Emergency decon must be set up prior to performing any rescue for your protection as well as for the patients’ protection.

Plan Your Initial Response (continued)

Rescue Considerations (continued)

Risks Based on Hazard Class

NFPA's *Hazardous Materials/Weapons of Mass Destruction Response Handbook* identifies risks to rescuers based on hazard class. Many of those risks are summarized below. However, this list is not meant to be all-inclusive. Most risks exist with each hazard class to a greater or lesser degree. (Hazard classes are described in Chapter 3.)

- *Class 1 - Explosives.* Burn injuries and mechanical injuries from the shock, blast overpressure, fragmentation, shrapnel, or structural damage are common. Other possibilities include chemical contamination, exposure to bloodborne pathogens from injured victims, and asphyxiation from depleted oxygen.
- *Class 2 - Gases.* Risks vary with the type of gas (toxic, flammable, etc.). Displaced oxygen can create an asphyxiation risk, especially with cryogenic liquids. Cryogenic materials can cause frostbite. Sudden failure of a pressurized container can cause mechanical injury.
- *Class 3 - Flammable and Combustible Liquids.* The risks include burns if the material ignites and mechanical injury if the container forcefully ruptures.
- *Class 4 - Flammable Solids, Spontaneously Combustible Materials, and Dangerous When Wet Materials.* Burn injuries can result from fire or from the heat generated in a chemical reaction. Water-reactive materials may produce toxic gases, flammable gases, and/or corrosive solutions.
- *Class 5 - Oxidizers and Organic Peroxides.* Burn injuries are a concern, because these materials support combustion. The unstable and explosive nature of organic peroxides presents risks similar to those of Class 1 materials.
- *Class 6 - Poisonous and Infectious Substances.* Toxicity is the primary hazard with poisonous substances. Some of these materials are flammable, so burn injuries are possible. Infectious agents cause diseases, some of which can be fatal.
- *Class 7 - Radioactive Materials.* Radiation sickness and burns are possible. (See Chapter 11 for details.) Radiological substances may have other chemical hazards too.
- *Class 8 - Corrosives.* The greatest risk is chemical burns. Inhalation of vapors can also cause respiratory damage.
- *Class 9 - Miscellaneous Dangerous Goods.* The risks vary.

Plan Your Initial Response (continued)

Rescue Considerations (continued)

The ERG - Implied Rescue Considerations

While the ERG doesn't expressly state whether you can safely attempt a rescue, the health hazards identified in the guide pages reflect the degree of risk you might face in trying to rescue someone. If a guide says "may be fatal if inhaled or absorbed through the skin" or "inhalation or contact (skin, eyes) with vapors, dusts, or substance may cause severe injury, burns or death," any openings in your PPE put you at greater risk of injury. This doesn't mean you *can't* do a rescue if the odds are in your favor. However, it does mean the risks are higher.

The SBCCOM Report - Guidelines for WMD Incidents

What about WMD incidents? The U.S. Army SBCCOM Domestic Preparedness Chemical Team published a report in 1999 to address whether firefighters can safely effect a rescue after a terrorist attack with a chemical warfare agent. The report was revised in 2003 based on input from the fire service and on newly published chemical, biological, radiological, and nuclear (CBRN) PPE standards.

SBCCOM recommends that firefighters wear CBRN-certified chemical protective clothing if available. However, firefighters may not know what they're dealing with right away and may not have CBRN-certified PPE at their disposal. Then what? Ultimately, it's up to each jurisdiction and/or the on-scene incident commander to decide if it's worth the risk to attempt search and rescue operations. The SBCCOM report is merely a tool to help make an informed decision.

Assuming they follow the operational restrictions in the SBCCOM report (summarized on the following page), properly trained and equipped firefighters should be able to accomplish a quick and effective rescue without significant risks. However, firefighters in standard turnouts and SCBA are subject to greater risk of chemical effects than they would be if using CBRN-certified equipment. It's expected that half of the firefighters may experience threshold effects for chemical exposure.

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Plan Your Initial Response (continued)

Rescue Considerations (continued)

The following basic operational considerations and conditions summarize the contents of the 2003 SBCCOM report:

- The presence of **living** victims inside the potential hazard area provides a basic indicator (in the absence of atmospheric monitoring) for firefighters to assess the level of nerve agent contamination. If at least 2 percent (1 in 50) of the victims are still alive 10 minutes after the incident, rescuers can assist those victims with little or no risk (threshold symptoms at worst) while wearing standard turnout gear with SCBA. Live victims indicate that the nerve agent concentration is relatively low compared to concentrations achievable.
- Rescuers will likely enter the hazard area after the vapor concentration has peaked (assumed approximately 10 minutes after release of agent).
- Firefighters using standard turnout gear and SCBA to perform rescue of **known live victims** can operate in a nerve agent vapor environment for up to 30 minutes with minimal health effects. (It is estimated that 50% of firefighters may experience increased sweating and muscle weakness 1 to 18 hours after exposure.)
- Firefighters using standard turnout gear and SCBA to enter a nerve agent environment **without known live victims** should limit their potential exposure to 3 minutes.
- Firefighters searching an enclosed area for victims should immediately exit the area and undergo decontamination if they encounter evidence of chemical contamination and cannot identify any living victims.
- Predicted health effects are based on the assumptions that:
 - Firefighters will avoid contact with any unidentified liquids.
 - Firefighters and rescued victims will undergo emergency decon immediately upon exiting the potentially hazardous area.
- If firefighters encounter oily liquid contamination (puddles/drops) and victims report signs of mustard agent (i.e., garlic odor), firefighters and victims should immediately exit the area and undergo decontamination.
- Emergency medical services must be immediately available on scene.

(continued next page)

Plan Your Initial Response (continued)

Rescue Considerations (continued)

Below are some other key points from the 2003 SBCCOM report:

- The report is based on testing firefighter protective ensembles against chemical agent *vapor* only. It does not address *aerosol* or *liquid* hazards. However, turnouts generally provide better protection against aerosols than they do against vapors.
- Improperly fitted SCBA may result in inhalation and eye exposure. The first indication of eye exposure is miosis; the pupils constrict, making it more difficult to see in low light levels. Responders experiencing miosis should exit the area immediately.
- Signs and symptoms of mustard (HD) exposure can be delayed by several hours. Therefore, it's not possible to gauge relative mustard concentrations by observing victim responses the way it is with nerve agents. In the absence of immediately recognizable signs and symptoms, responders must consider other clues, such as victim reports of a garlic-like odor, presence of an oily liquid or spray, and presence of a spray device.
- If possible, victims should be removed from a building through doors or windows that lead directly to the outside.
- Positive pressure fans used to ventilate the structure can significantly reduce chemical agent vapor concentration. However, ventilation doesn't destroy the vapors; it merely moves them into other areas that must be evacuated before ventilating.
- Responders and victims exiting the scene must immediately undergo water-based decon (high volume, low pressure).
- Information in the SBCCOM report can't be used to justify the use of turnout gear and SCBA for any purpose other than lifesaving rescue operations.
- In light of the new CBRN standards, the 2003 SBCCOM report eliminates "quick fix" options, such as taping openings with duct tape or wearing a Tyvek suit under turnouts.

Plan Your Initial Response (continued)

Personnel Accountability

Any response to a hazmat incident or terrorist event should include a personnel accountability system so that the incident commander knows where all personnel are at all times and can rapidly account for everyone in the event of an emergency.

- Initiate an accountability system at the beginning of operations, and maintain the system throughout. Update the system as personnel, assignments, and locations change.
- Ensure that all personnel comply with the accountability system.
 - Have all personnel check in at the command post or staging location, as appropriate.
 - Have supervisors maintain an ongoing awareness of the location and condition of personnel under their supervision.
 - Have all personnel remain under the supervision of those to whom they've been assigned until they are reassigned or released from the incident. There should be no freelancing.
 - When personnel are ready to leave the scene, have them check out through their supervisors or the command post.
- If mission duration must be limited due to air supply, the potential for heat exhaustion, or other reasons, assign a timekeeper to monitor the operation and provide time updates to personnel.
- Include a notification system (e.g., with radios, loud speakers, or air horns) to alert personnel to emergencies on site.

Mayday Procedures

NFPA 470 defines a mayday as any situation at a hazmat/WMD incident where an entry team member is unable to safely exit the hot zone or an event cannot be resolved by the entry team member within 30 seconds. Any responder can initiate a mayday, so everyone should be familiar with the basic procedures.

- Call "Mayday, Mayday, Mayday" to ensure priority radio traffic.
- Without unkeying the mic, identify yourself, the cause of the mayday, your location, and what is needed to help resolve the mayday.
- Begin self assessment / self-rescue.
- Stay calm, conserve air, and activate your PASS device if that will help the mayday situation.
- Maintain radio contact with command.
- Initiate additional actions as appropriate.

Plan Your Initial Response (continued)

Rest and Rehabilitation

The incident commander should make suitable provisions for the rest and rehabilitation of response personnel. This is particularly important for those working in PPE, but it applies to everyone on scene.

- Request resources early. It almost always takes longer for resources to arrive than you anticipate. As soon as it becomes apparent that the incident will be extended, start thinking about backup personnel, water, food, lighting, etc.
- Ensure that personnel operating in chemical protective clothing are medically monitored pre- and post-entry into a hot zone. (See pages 6-33 to 6-34 for more information.) (Note: Medical monitoring for *all* personnel in protective clothing at the scene is strongly recommended, regardless of their assignment.)
- Make sure that advanced first aid personnel are standing by with treatment and transport capability.
- Provide fluids.
- Provide food if the incident will be extended.
- Remind personnel to wash their hands before eating, drinking, or smoking.
- Provide a rest area away from the noise and commotion and sheltered from extreme climactic conditions. Make sure the area is equipped with chairs, benches, or other comfortable places to relax.
- Make sure the rest area is equipped with clean toilets or that clean toilets are available nearby.
- Make sure personnel are given adequate time for rest and rehabilitation. Rest time should at least equal suit time. Longer times may be necessary.
- Make sure that all personnel entering and leaving the rehab area are tracked through the personnel accountability system.

All personnel must also be responsible for communicating rest and rehab needs to their supervisors. It's not enough to rely solely on safe practices and medical monitoring. Everyone must work together to ensure the well-being of personnel on scene.

Plan Your Initial Response (continued)

Key Points About Planning

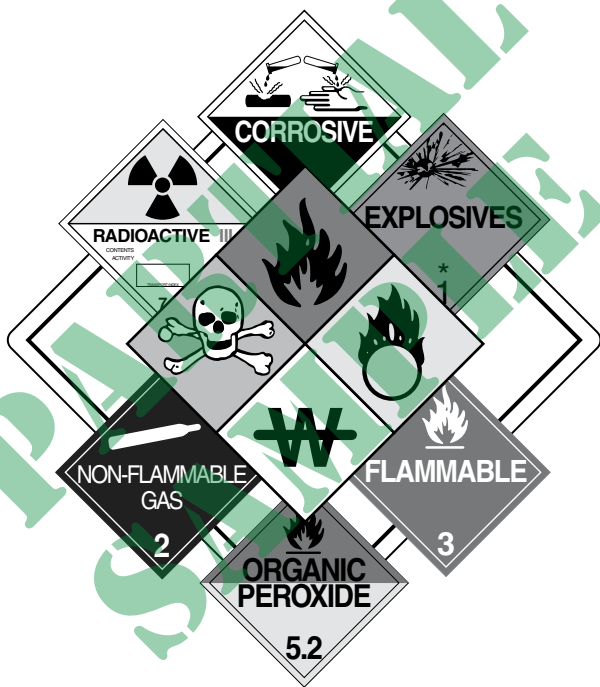
- Look at the big picture. Maintain situational awareness.
- Base your plan on solid product identification and hazard assessment, as well as on SOPs, not on guesswork.
- Do a risk-versus-gain analysis. What favorable impact will intervention make? What are the possible risks of intervention?
- Plan a response that stays within the limits of your training, resources, and equipment.
- Use the safest and simplest method to get the job done.
- Be expedient, but remember that the quickest method is not necessarily the safest or the best.
- Use nonsparking or intrinsically safe equipment in the presence of flammable vapors.
- Include proper safety precautions and a contingency plan for unexpected emergencies in your incident action plan (IAP).
- Review the incident action plan for all personnel during a safety briefing prior to undertaking any operations.
- Document your incident action plan.
- Designate a scribe to record decisions, activities, and problems as they occur. It is difficult to take care of your responsibilities and document activities at the same time. Notes taken during the incident will be invaluable during the debriefing, as well as when you try to document the entire incident later.

Compliance with 29 CFR 1910.120

As a final checklist, make sure your incident action plan contains the following minimum components required by 29 CFR 1910.120. All should be built in to your pre-event contingency plans, but some may have to be modified to fit individual incidents.

- Pre-emergency planning and coordination with outside parties
- Personnel roles, lines of authority, training, and communication
- Emergency recognition and prevention
- Safe distances and places of refuge
- Site security and control
- Evacuation routes and procedures
- Decontamination
- Emergency medical treatment and first aid
- Emergency alerting and response procedures
- Critique of response and follow-up
- PPE and emergency equipment

Labels, Placards and Other Marking Systems



This chapter provides information on how to recognize hazmat incidents through labels and placards, the NFPA 704 system, HMIS® labels, GHS (Globally Harmonized System) pictograms, and various other marking systems. This chapter also contains important safety information about each of the hazard classes.

Class 1 - Explosives (and Blasting Agents)

An explosive is any substance or article (including a device) that is designed to function by explosion or that, by chemical reaction within itself, is able to function in a similar manner. Explosives range from being very sensitive to shock, heat, or friction, to being relatively insensitive, needing an initiating device to function. They are divided into six divisions based degree of hazard.

Div.	Degree of Hazard	Examples
1.1	Mass explosion hazard	Black powder, dynamite, TNT
1.2	Projection hazard	Detonating cord, aerial flares
1.3	Fire/minor blast hazard	Propellant explosives, rocket motors
1.4	Minor explosion hazard	Practice ammo, common fireworks
1.5	Very insensitive	Blasting agents, ANFO
1.6	Extremely insensitive	Articles not otherwise specified



- Placards may or may not feature the explosives symbol and may or may not contain any text beyond the class and division number. (The asterisks are placeholders for compatibility group and division. Details are beyond the scope of this book.)
- One reason explosives are so dangerous is that they contain both an oxidizer and a fuel component in their structures. Two sides of the fire triangle are already complete.
- Many emergency responders have been killed by explosives because they underestimated the hazard potential.
- There is little difference between the six divisions from the first responder's perspective. While the degree of risk varies, all Class 1 materials can be just as deadly if they explode.
- Responders must never fight a fire involving explosives. ERG Guide 112 recommends evacuating to a distance of 1/2 to 1 mile (800 to 1600 meters), depending on the circumstances.
- It *may or may not* be safe to fight a fire that *threatens* explosives (e.g., vehicle tire fire, cab fire). Follow department SOPs.
- Some explosive devices (e.g., electric blasting caps) can be set off by radio transmissions. Do not operate radios within 330 feet (100 meters) unless you are sure it's safe to do so.
- Improvised explosive devices (IEDs) are very dangerous because they can be easily concealed and triggered in many ways.

Class 2 - Gases

Div. Description

- 2.1 Flammable gas (e.g., propane, acetylene, methyl chloride)
- 2.2 Nonflammable, nonpoisonous compressed gas (including compressed gas, liquefied gas, pressurized cryogenic gas, compressed gas in solution, asphyxiant gas, and oxidizing gas) (e.g., anhydrous ammonia, carbon dioxide, nitrogen)
- 2.3 Gas poisonous by inhalation (identified as *inhalation hazard* in the U.S. or *toxic gas* internationally) (e.g., arsine, chlorine, phosgene, methyl bromide)



- Class 2 materials all exist as gases in their natural states.
- The words *poison* and *poisonous* are synonymous with *toxic*.
- Division 2.1 gases have (1) a lower explosive limit (LEL) of 13% or less or (2) a flammable range of at least 12%, regardless of the LEL. Beware of “nonflammable” gases (e.g., anhydrous ammonia) that will burn in the right concentration.
- Anhydrous ammonia shipments from Canada may have a Class 2.3 placard or 1005 placard (pictured above right).
- Overpressurization can cause pressure vessels to fail catastrophically. Consider an immediate withdrawal.
- Large pressure vessels can fail in 10 to 20 minutes or days after the container was stressed. BLEVEs (boiling liquid expanding vapor explosions) can throw debris up to a mile. If enough water is not available to cool the vapor space and any part of a pressure vessel exposed to flame impingement within the first 10 minutes, consider an immediate withdrawal.
- A rising sound from a venting relief device and discoloration of the tank due to fire are indications of impending BLEVE. Withdraw immediately.
- Most compressed gas cylinders have a pressure relief device to prevent rupture when exposed to fire. (Relief devices are prohibited on cylinders containing highly toxic materials.)
- When gases are released quickly from a cylinder, the cylinder can become very cold. Beware of the frostbite hazard.
- A liquid released from a pressure vessel will expand significantly as it returns to its gaseous state. The gas can travel a considerable distance and greatly increase the scope of the incident.

(continued next page)

Class 2 - Gases (continued)

- Division 2.3 (poisonous) gases are further identified by poison inhalation zone (PIH), sometimes referred to as toxic inhalation zone (TIH). Hazard Zone A is the worst.

Zone	LC ₅₀ greater than	LC ₅₀ less than or equal to
A	—	200 ppm
B	200 ppm	1000 ppm
C	1000 ppm	3000 ppm
D	3000 ppm	5000 ppm

Cryogenic Liquids

Class 2 also includes cryogenic liquids (gases that have been liquefied by cooling to a temperature of -130°F/-90°C or less).

There is no label or placard specifically for cryogenic liquids. They generally have the same labels or placards used for gases. However, many containers used for bulk transportation of cryogenic liquids are not placarded; they are stenciled with the words "Refrigerated Liquid" and the name of the product instead.

Cryogenic liquids present several hazards:

- They are extremely cold; contact can cause frostbite.
- Cryogenic liquids have very high expansion ratios. Liquid nitrogen, for example, has an expansion ratio of 696 to 1. A large release of a cryogenic liquid could displace oxygen in the atmosphere and create an asphyxiation hazard, particularly in enclosed spaces or low-lying areas.
- The high expansion ratio also means that any flammability or toxicity risk is greatly increased because there is so much more volume of product present in a release.
- Some cryogenic liquids form extremely shock-sensitive mixtures when in contact with combustible materials (e.g., liquid oxygen on asphalt).
- Cylinders or tanks containing cryogenic liquids may fail catastrophically (BLEVE) when exposed to flame, radiant heat, or other high temperatures. They should be handled much like pressure vessels in an emergency.
- If the tank has been damaged and the insulation compromised, there is an added danger of the product warming much faster than it would in an intact tank. Even exposure to ambient air or water from firefighting efforts will increase the risk.

Class 3 - Flammable and Combustible Liquids

Flammable Liquids

Flammable and combustible liquids are distinguished by flash point. Flammable liquids (e.g., gasoline, acetone, toluene, and methyl alcohol) are generally defined by the DOT as those with flash points not more than 140°F (60°C), whereas combustible liquids (see next page) have flash points above 140°F (60°C). Simply put, flammable liquids can ignite easily at ambient temperatures, whereas combustible liquids must be heated first.



Caution: Always check the properties of flammable and combustible liquids rather than take placards at face value. The DOT allows some Class 3 flammable liquids with flash points at or above 100°F (37.8°C) to be reclassified as combustible liquids for transportation. Conversely, some combustible liquids that are intentionally heated and transported at or above their flash points may be placarded as flammable liquids.

- The vapors of flammable liquids are heavier than air and will not dissipate rapidly. Try to eliminate ignition sources *if you can do so safely*. Firefighters may need to suppress vapors with foam.
- Closed containers exposed to direct flame impingement are likely to fail unless cooling water is applied quickly. The liquid space is protected as long as there is sufficient liquid to absorb the heat. Direct initial fire streams toward the more vulnerable vapor space whenever there is flame impingement.
- Gasoline, one of the most common products involved in hazmat incidents, is generally transported in aluminum cargo tanks that will melt when exposed to fire and can fail rapidly, thereby creating a major containment problem.
- Using water on some flammable liquid fires (e.g., gasoline) can dramatically spread the fire if the product and water are not confined. Sometimes it's better to let the product burn and protect exposures instead.

(continued next page)

Class 3 - Flammable and Combustible Liquids (continued)

Flammable Liquids (continued)

- The effectiveness of foam or water in suppressing flammable liquid vapors depends on the specific gravity of the product. (See pages 5-44 and 5-45 for information on specific gravity.)
- An oxygen-enriched atmosphere (>23.5%) or the presence of oxidizers will greatly intensify fires involving flammable liquids.
- **Warning: The word *inflammable* means *flammable*. It does not mean nonflammable.**

Combustible Liquids

A combustible liquid (e.g., fuel oil, mineral oil, and peanut oil) is one that does not meet the definition of any other hazard class and has a flash point above 140°F (60°C) and below 200°F (93.3°C).



A placard with the 4-digit identification number and a white triangle below it (above left) identifies the product as a combustible liquid rather than a flammable one.

- Combustible liquids are not easily ignited at ambient temperatures; they must be heated first.
- Combustible liquids are easier to ignite in hot environments (e.g., if spilled on hot asphalt on a hot day) than they are normally.
- Oxygen-enriched atmospheres (>23.5% oxygen) can cause combustible liquids to ignite more easily and burn more intensely. Combustible liquids will behave similarly to flammable liquids under these conditions.
- Oxidizers mixed with combustible liquids can produce explosive combinations (e.g., ammonium nitrate and fuel oil).
- Many of the guidelines for dealing with flammable liquids are also appropriate for combustible liquids.

See pages 5-23 to 5-47 for more information on chemical and physical properties of flammable liquids, combustible liquids, and other materials.

Class 4 - Flammable Solids, Spontaneously Combustible Materials, and Dangerous When Wet Materials

This class includes any solid material, other than an explosive, that is liable to cause fires through friction or through retained heat from manufacturing or processing. It also includes solids and liquids that can be ignited readily on exposure to water or air or that are highly reactive to water or air.

Div. Description

- 4.1 Flammable solids (desensitized explosives, self-reactive materials, and readily combustible solids) (e.g., magnesium [pellets, turnings or ribbons], nitrocellulose, matches)
- 4.2 Spontaneously combustible materials (pyrophoric and self-heating materials) (e.g., aluminum alkyls, charcoal briquettes, magnesium alkyls, phosphorus)
- 4.3 Dangerous when wet materials (e.g., magnesium powder, calcium carbide, sodium, potassium)



- Flammable solids burn vigorously and persistently once ignited. Metal shavings, dusts, or powders can be very dangerous under the right conditions, because there is so much surface area available to burn. Combustion can be so rapid and produce sufficient pressure that it results in a dust explosion.
- Small fires involving combustible metals require the use of special Class D extinguishing agents.
- The use of water, carbon dioxide, or halon can greatly accelerate a fire involving many Class 4 materials. It may be more appropriate to let large fires burn and protect exposures instead. Follow your department SOPs.
- Burning metals produce hazardous gases that may be toxic, corrosive, or asphyxiating.
- Many of the water-reactive materials will produce flammable and/or toxic gases when mixed with water. Some also produce very caustic (corrosive) solutions.

Class 5 - Oxidizers and Organic Peroxides

Div. Description

- 5.1 Oxidizers (e.g., ammonium nitrate, bromine trifluoride, calcium hypochlorite)
- 5.2 Organic peroxides (e.g., dibenzoyl peroxide, methyl ethyl ketone peroxide, peroxyacetic acid).



- Oxidizers may cause or enhance combustion of flammable or combustible materials by yielding oxygen or other oxidizing agents. The reactions can be violent and explosive.
- Firefighting clothing contaminated with an oxidizer will burn vigorously and may need to be discarded.
- Organic peroxides are flammable and unstable; they are more dangerous than ordinary oxidizers are.
- Organic peroxides are similar to explosives; they contain a fuel and an oxidizer in the same formula. Do not attempt to fight a fire. Withdraw to a safe distance—at least 2000 feet (600 meters).
- Some organic peroxides can form extremely unstable, shock-sensitive crystals on the outside of the container if exposed to air. Request assistance from a hazmat team or bomb squad.
- Oxidizers and organic peroxides can react violently to friction, temperature, or contamination.
- Organic peroxides may be prone to runaway polymerization and catastrophic container failure (signified by a "P" next to the guide number in the yellow and blue sections of the ERG).
- If an organic peroxide reaches its self-accelerating decomposition temperature (SADT), it will decompose in a dangerous reaction that can't be stopped. Organic peroxides should be kept below their maximum safe storage temperature (MSST), which provides a margin of safety to prevent getting to the SADT.
- Organic peroxides are divided into 7 types (A through G) based on whether they detonate or deflagrate and how they behave when heated under confinement. Type A is the most hazardous.

Class 6 - Poisonous and Infectious Substances

While all chemicals may be toxic to some degree, toxicity is the primary threat with these materials. (Refer to Chapter 5 for more information on toxicology.) Class 6 has two divisions:

Div. Description

- 6.1 Poisonous materials (signified by *Poison*, *Inhalation Hazard*, or *PG III*) (e.g., aniline, arsenic, hydrocyanic acid, carbon tetrachloride, tear gas)
- 6.2 Infectious substances (labels only, not placards) (e.g., anthrax, botulism, rabies, tetanus)
Includes Category B Biological Substances (UN3373)



- Structural firefighting clothing and SCBA may *not* provide sufficient protection. Avoid contact with poisonous or infectious substances. Request assistance from a hazmat team.
- Other good sources for information include your local poison control center, CHEMTREC, or the CDC.
- It is sometimes best to allow fires involving these materials to burn. Fire can destroy the toxic properties of some products, thus decreasing the danger. Allowing the fire to burn also minimizes spread of the product from runoff.
- Pesticide container labels must include a signal word: *Danger* (high toxicity), *Warning* (moderate toxicity), or *Caution* (relatively low toxicity). The word *Poison* and a skull and crossbones icon must be added if the product fits into the high toxicity category based on oral, inhalation, or dermal toxicity (as distinct from skin and eye irritation).
- Pesticide container labels must also contain a flammability statement: *Extremely Flammable*, *Flammable*, *Combustible*, or *Contents Under Pressure*.
- Division 6.1 materials are assigned to packing groups (PG I, II, or III). Packing Group I (PG I) is the most hazardous. Within Packing Group I are two hazard zones (A and B). Zone A materials are the most dangerous.

Class 7 - Radioactive Materials

Radioactive materials (e.g., cobalt, uranium hexafluoride, and “yellow cake”) are covered in depth in Chapter 11.



- The Radioactive I, II, and III labels (first three above) reflect the radiation level as measured both at the surface of the package and 1 meter (3 feet) away. (See page 11-20.) Radioactive I is the least hazardous, while Radioactive III is the most hazardous.
- Fissile labels are used for fissile materials (also called *special nuclear materials*) that can be used to create an atomic bomb.
- The radioactive placard (far right) is required only when transporting Radioactive III materials.
- Radiation cannot be seen or smelled. It can be detected only with special instruments.
- Protection from radiation requires a combination of time, distance, and shielding. (See pages 11-11 to 11-15.)
- Structural firefighting clothing and SCBA will protect against alpha and low-energy beta particles, but it won't protect against penetrating radiation. (See page 11-15.)
- An initial control zone should be set where radiation levels are at or below 2 mR/hr above background level. If you can't confirm radiation levels, use minimum distances in ERG Guide 163:
 - Isolate 75 feet (25 meters) for a spill or leak.
 - Evacuate downwind 330 feet (100 meters) for large spills.
 - Evacuate 1000 feet (300 meters) for a major fire.
- Whether you can safely extinguish a fire or should allow it to burn will depend on the degree of risk. Do as little overhaul as possible once the fire is out. Contact your state or local radiological officer or health department for assistance.
- Radiation exposures should be kept as low as reasonably achievable (ALARA). The U.S. EPA recommends the following radiation dose limits for emergency services:
 - 5 rem whenever possible
 - 10 rem to protect valuable property (if a lower dose is not practicable)
 - 25 rem to save a life or protect large populations (if a lower dose is not practicable)

These limits are based on hour-long exposures. You can exceed these limits for shorter exposures. (See page 11-10.)

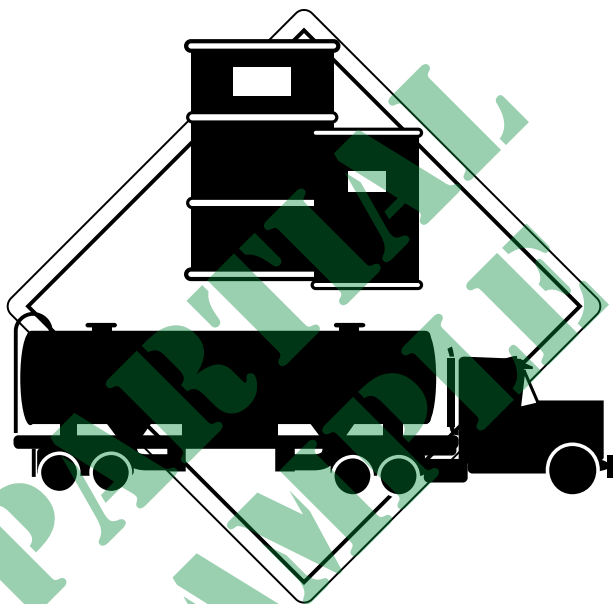
Class 8 - Corrosive Materials

Corrosives (e.g., sulfuric acid, nitric acid, and sodium hydroxide) are materials that degrade metals and cause destruction to living tissue on contact. Corrosives can be solids or liquids. They are divided into two categories: acids and bases. Bases can also be referred to as caustics or alkalis.



- The *strength* of a corrosive is measured by pH. The pH scale goes from 0 to 14, with 7 being neutral. Materials with a pH from 0 to 6 are acidic. The closer to 0, the stronger the acid. Materials with a pH from 8 to 14 are basic. The closer to 14, the stronger the base.
- Corrosives are also measured in terms of *concentration*, which is independent of strength (pH). Concentration refers to the percentage of an acid or base in water. A concentrated acid or base is more hazardous than a less concentrated one.
- Protection from corrosives generally requires the use of chemical protective clothing and SCBA. Vapors can permeate the fabric of a work uniform or structural firefighting clothing and cause severe irritation or damage, especially to mucus membranes and moist skin.
- Smoke from burning corrosives is also very dangerous. It may be more appropriate to let these materials burn and protect exposures instead. Follow your department SOPs.
- Foam or fog streams may be used to disperse or redirect vapors in a release. However, keep the water away from the container and the spill, because adding water to a concentrated corrosive can cause a very violent reaction.
- Acids and bases are not compatible with each other. Although acids and bases can sometimes be used to neutralize each other by a trained hazmat team or chemical expert, mixing strong acids and bases can lead to a fire or explosion and severe injury or death. Do not try to mix acids and bases. Let the experts determine if neutralization is appropriate.
- Acids are not compatible with most metals. Contact with metal may produce highly flammable hydrogen gas.
- Some acids are incompatible with other acids.
- Some acids are flammable. Some are strong oxidizers.
- See also pages 5-46 and 5-47 for information on corrosivity.

Container Recognition



All first responders should have a basic understanding of some of the containers used to store or transport hazardous materials, their likely contents, and how different containers will behave in an emergency.

This chapter addresses container recognition, general safety considerations, and the hazards associated with specific containers. However, it is beyond the scope of this book to provide instructions for handling specific emergencies involving these containers. Refer to your department SOPs, the *Emergency Response Guidebook*, or other appropriate resources for more information.

Cargo Tanks

Some cargo tanks can hold up to 12,000 gallons (45,425 liters) of liquid. However, the release of a compressed or liquefied gas will fill a much greater volume due to the high expansion ratio.

Cargo Tank Markings and Features

The illustrations and descriptions in this book are generalizations only and should not be relied upon for positive identification. For example, many MC-306 or DOT-406 cargo tanks have an elliptical appearance from the rear, but some appear circular instead. Some cargo tanks have insulation that can hide distinguishing characteristics.

- Common tank markings include company names and logos, vehicle or tank identification numbers, license plate numbers, and placards.
- Some cargo tanks are stenciled with the commodity name for easy identification.
- Tank color, though not always a reliable indicator, can sometimes provide an additional clue about the type of product being transported. For example:
 - High-pressure tanks generally have at least the top two thirds painted white.
 - Corrosive tank trucks sometimes have a contrasting color band of corrosive-resistant paint or rubber material on the tank in line with the manway.
- A manufacturer's specification plate near the front of the tank (on either side) provides information about the tank design and construction. If information about the product is not available, it might be possible to determine what type of material is being transported based on the tank specifications.
- Most tanks transporting hazardous materials have a manual emergency valve control (EVC) or shutoff device located near the front left fender (driver's side). Some have two shutoff devices, one on each side of the trailer. Many of these devices have a fusible link that operates automatically in a fire.
- Tanks transporting hazardous materials must have shear or crash box protection for internal safety valves and rollover protection for the dome lid and vents on top. A tank without these safety features is most likely transporting a nonhazardous and/or food grade commodity.

Cargo Tanks (continued)

General Incident Guidelines

In general, first responders should not attempt offensive control options for a hazmat incident involving cargo tanks. The following are some basic guidelines to supplement your department SOPs:

- View incidents from a safe distance.
- Use binoculars to look for placards or other clues that hazardous materials might be present.
- Obtain shipping papers from the driver if possible. The *bill of lading* or *freight bill* is kept in the cab within easy reach of the driver. If the vehicle is unattended, the driver is supposed to leave shipping papers in a pouch on the door or lying on the driver's seat.
- Request assistance from the shipper, CHEMTREC, or a trained hazmat team. Provide an accurate, detailed description of placards, container shape and markings, condition of the tank, and circumstances of the incident.
- Whenever possible, use the truck driver or trucking company for technical assistance regarding vehicle operation.

Gasoline Tanker Incidents

Gasoline is the most common commodity transported on our nation's highways. It is generally transported in atmospheric pressure cargo tanks (MC-306 or DOT-406) as described on page 4-24. All fire departments should have procedures in place for dealing with fires or spills involving gasoline tankers.

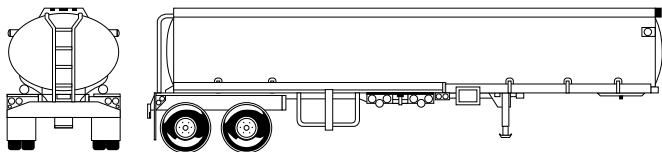
In the event of a **spill**, the priorities are to contain the product and prevent ignition *if safe to do so*:

- Eliminate ignition sources.
- Cover nearby storm drains.
- Dike the product.
- Use foam lines to suppress flammable vapors if appropriate.

Because water supplies are often limited at highway accidents, it might be necessary to let a gasoline **fire** burn and protect exposures instead. Firefighters must also weigh the risk of further spreading the fire by applying water or foam. Containing the product and any runoff water might be a higher priority than extinguishment.

Cargo Tank Trucks (continued)

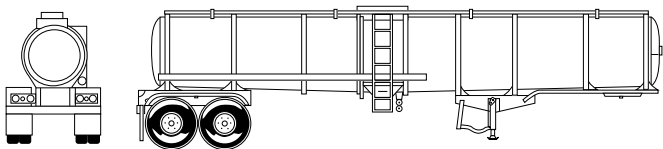
Atmospheric-Pressure (Nonpressure) Cargo Tanks (MC-306/DOT-406)



- Atmospheric-pressure cargo tanks (or nonpressure cargo tanks) are used to transport flammable liquids, such as gasoline, diesel or jet fuel, and kerosene, as well as combustible and poison liquids. However, some contain liquid food products.
- Over 90% of these tanks are constructed of aluminum, which is more susceptible to tears and punctures than comparable steel tanks are.
- Overturned aluminum tankers generally must be offloaded before being uprighted to avoid further container failure.
- Aluminum tanks will melt when exposed to flame and can fail rapidly, thereby creating a major containment problem.
- Take capacity can range from 2000 to 10,000 gallons (7571 to 37,854 liters). Some have multiple compartments, each with different products. Determine the number of compartments by counting the number of discharge valves.
- Up to 40 gallons (151 liters) of product can be in the bottom piping before the first delivery is made. In the event of a leak, try to determine if the product is coming from the tank or the bottom piping. It can make a difference in how the incident is handled and the resources required to mitigate it.
- The oval cross section signals an atmospheric-pressure cargo tank designed to withstand very low pressures (less than 4 psi).
- Aluminum tanks may or may not be designed to support the weight of a full load resting on the landing gear. Never disconnect a tractor from a fully loaded aluminum shell tank without direction from the driver, tank manufacturer, or other reliable source. The landing gear may puncture the shell.
- Static electricity is a hazard with these tanks. Equipment must be bonded and grounded when transferring product.
- These tanks can also be referred to as MC-306 or DOT-406 depending on when they were constructed and the specifications to which they were built.
- *(See also the general comments on pages 4-22 and 4-23.)*

Cargo Tanks (continued)

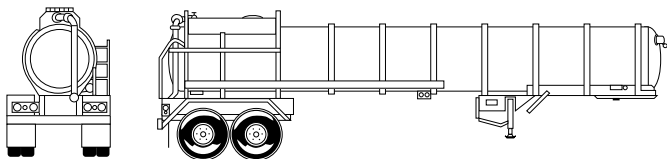
Low-Pressure Cargo Tanks (MC-307/DOT-407)



- Low-pressure cargo tanks are used to transport flammable and combustible liquids, mild corrosives, some poisons, and a wide variety of other liquids.
- Most of the tanks are constructed of stainless steel, which is harder but more brittle than comparable tanks made of mild steel or aluminum.
- Stainless steel begins to sustain damage at temperatures above 1200°F (649°C) and significant loss of strength at 1500°F to 1600°F (816°C to 871°C). Tanks constructed of any other type of steel will likely fail at comparable temperatures.
- Many of the tanks are insulated to protect temperature-sensitive commodities.
- Tank capacity is generally between 2000 and 7000 gallons (7570 and 26,498 liters) of product.
- Low-pressure cargo tanks are generally designed to withstand pressures of up to 40 psi.
- These tanks may or may not be compartmented.
- Some low-pressure cargo tanks have external stiffening rings, as illustrated above. However, many do not.
- These tanks can also be referred to as MC-307 or DOT-407 depending on when they were constructed and the specifications to which they were built.
- (See also the general comments on pages 4-22 and 4-23.)

Cargo Tanks (continued)

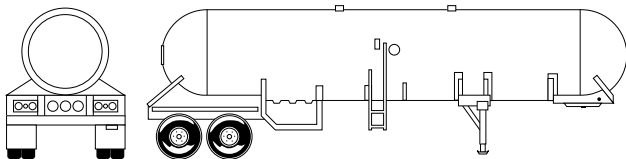
Corrosive Liquid Cargo Tanks (MC-312/DOT-412)



- Corrosive liquid cargo tanks are used to transport corrosive liquids and other heavy or high-density liquid products. They can also be used to transport water.
- Most are made of mild or stainless steel, though some are made of aluminum.
- Some corrosive liquid tanks are protected with a lining made of rubber, glass, or other materials.
- These tanks generally contain between 3300 and 6300 gallons (12,492 to 23,848 liters) of product. They are generally built as a single compartment, but some have multiple compartments.
- Corrosive liquid cargo tanks are smaller than many other tanks because they carry heavier products.
- Corrosive liquid cargo tanks can generally be distinguished by circular cross sections and external stiffening rings that provide tank for added strength. However, some of these tanks have insulation or jackets that can conceal some of the distinguishing characteristics. (Other tanks may have external rings too, but these other tanks are larger in diameter than those used for corrosive liquids.)
- Corrosive liquid cargo tanks may have a contrasting color band of corrosive-resistant paint or rubber material that circles the tank in line with the manway.
- The normal maximum allowable working pressures are between 35 and 50 psi. Rare versions may operate at pressures up to 100 psi.
- These tanks can also be referred to as MC-312 or DOT-412 depending on when they were constructed and the specifications to which they were built.
- (See also the general comments on pages 4-22 and 4-23.)

Cargo Tanks (continued)

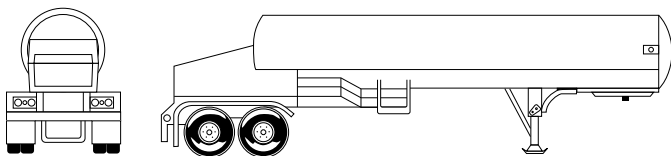
Pressure Cargo Tanks (MC-331)



- High-pressure cargo tanks are used to transport LPG, chlorine, anhydrous ammonia, and other gases that have been liquefied through compression.
- Most pressure cargo tanks are constructed of steel, which loses its tensile strength when exposed to high temperatures.
- These tanks can also be referred to as MC-331. The smallest ones are sometimes called *bobtails*.
- Direct flame impingement on the vapor space of a pressure vessel can cause catastrophic failure (BLEVE). Large pressure vessels can fail within 10 to 20 minutes or even days after the container is first stressed. BLEVEs have been known to throw debris almost a mile (1.6 km). The greatest danger is generally at the ends of the tank, but there is still significant risk at the sides. If an adequate water supply is not available to cool the upper part of the tank (vapor space) and any areas of direct flame impingement within the first 10 minutes, consider making an immediate withdrawal to a distance of 1 mile (1.6 km).
- A rising sound from a venting relief device and discoloration of the tank due to fire are indications of an impending BLEVE. Withdraw immediately.
- A liquid released from a pressure cargo tank will expand significantly as it returns to its gaseous state. Hazardous gases can travel a considerable distance from the source and greatly increase the scope of the incident.
- Pressure cargo tanks have circular cross sections and rounded (spherical) heads. The upper two thirds are generally painted white or another reflective color to reflect heat from the sun.
- The tanks are required to have emergency remote shutoff devices at opposite ends of the trailer (front left and right rear).
- Bobtails range from 2300 to 3000 gallons (8706 to 11,356 liters). Most larger tanks range from 9000 to 14,500 gallons (34,069 to 54,888 liters), though larger ones are allowed in some states.
- Pressure cargo tanks are designed to withstand pressures of 100 to 500 psi.
- (See also the general comments on pages 4-22 and 4-23.)

Cargo Tanks (continued)

Cryogenic Liquid Cargo Tank (MC-338)



- Cryogenic liquid cargo tanks are used to transport gases that have been liquefied through temperature reduction. Examples include liquid oxygen (LOX), nitrogen, and argon.
- These tanks should be handled much like pressure tanks for the purpose of emergency response.
- Cryogenic cargo tanks are subject to catastrophic failure (BLEVE) if exposed to flame, radiant heat, or other high temperatures. If the tank is exposed to flame, try to remove the source of the fire first. If it becomes necessary to use water to extinguish the fire, be careful not to spray water on the safety relief device. The escaping product will be cold enough to freeze the water and prevent the relief device from operating.
- If the outer tank has been damaged and the vacuum and insulation compromised, there is an added danger of the product warming much faster than it would in an intact tank. Dealing with the resulting increased pressure in the cryogenic liquid tank under these conditions is generally beyond the scope of the first responder. Contact the shipper, CHEMTREC, and/or a trained hazmat team for assistance.
- Cryogenic liquids are time-sensitive and cannot be stored in cargo tanks for too long before they warm up and expand.
- The tanks usually experience some normal venting as ambient temperatures cause the material to warm up and expand. Vapor “burping” from the relief valve is usually not indicative of a problem, although it often causes concern from citizens.
- These products have very high expansion ratios. A large release can displace oxygen in the atmosphere and create an asphyxiation hazard, particularly in enclosed spaces or low-lying areas. In addition, hazardous gases can travel a considerable distance and greatly increase the scope of the incident.

(continued next page)

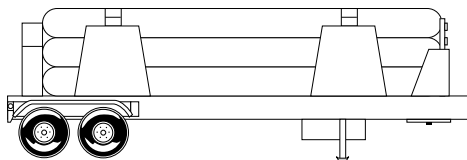
Cargo Tanks (continued)

Cryogenic Liquid Cargo Tank (continued)

- Cryogenic liquids are extremely cold (-130°F/-90°C or lower). Contact can cause severe frostbite injuries.
- Some cryogenic liquids form extremely shock-sensitive mixtures when in contact with combustible materials (e.g., liquid oxygen on asphalt).
- The vehicles usually have an inner steel tank surrounded by a vacuum insulation and a thin aluminum jacket. Fittings are contained in a cabinet at the center or rear of the truck.
- Cryogenic liquid cargo tanks commonly contain 8000 to 10,000 gallons (30,283 to 34,854 liters) of liquid product.
- Cryogenic liquid cargo tanks are generally have working pressures ranging from 25 to 500 psi.
- The tanks are generally stenciled with the name of the product or the words "Refrigerated Liquid."
- These tanks can also be referred to as MC-338.
- *(See also the general comments on pages 4-22 and 4-23.)*

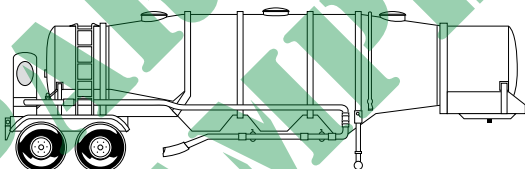
Cargo Tanks (continued)

Compressed Gas Trailer (Tube Trailer)



- Tube trailers carry multiple cylinders of compressed gases, such as oxygen, nitrogen, and hydrogen.
- Service pressures commonly range from 3000 to 5000 psi.
- Direct flame impingement can cause cylinders to fail catastrophically. Consider making an immediate withdrawal.
- These trailers are often found at construction and industrial sites.
- *(See also the general comments on pages 4-22 and 4-23.)*

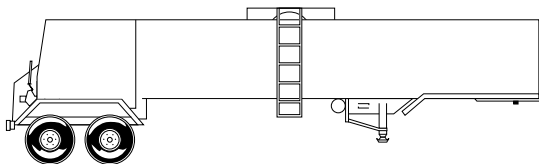
Pneumatically Offloaded (Dry Bulk) Hoppers



- Pneumatically offloaded hoppers, also known as dry bulk hoppers, carry dry materials such as ammonium nitrate fertilizer, dry caustic soda, plastic pellets, and cement.
- Many rollovers are caused by centrifugal force due to the very heavy loads these tanks carry.
- Static electricity is a common hazard with these cargo tanks. All equipment must be bonded and grounded when transferring product.
- *(See also the general comments on pages 4-22 and 4-23.)*

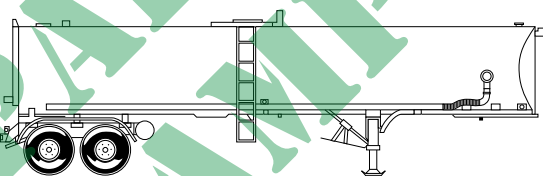
Cargo Tanks (continued)

Molten Sulfur Cargo Tanks



- Molten sulfur cargo tanks are hazardous primarily because the product is very hot (in excess of 250°F/121°C). It is not unusual for a fire to start once a spill occurs, because the sulfur runs down between the tank and the outer jacket, igniting the insulation.
- The tanks contain steel coils inside the shell to heat the sulfur.
- The tanks are required to be stenciled on the sides and ends with the words “Molten Sulfur.”
- (See also the general comments on pages 4-22 and 4-23.)

Asphalt Trailers

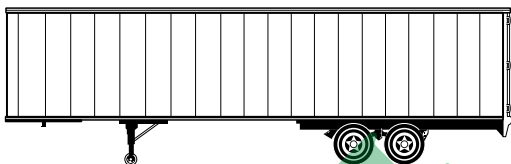


- Asphalt trailers transport asphalt cutback (a mixture of asphalt and a flammable or combustible liquid).
- Asphalt cutback may be regulated as a flammable liquid or a combustible liquid, depending on the flash point.
- These vessels consist of an inner tank covered by insulation and an outer jacket.
- Although these tanks do not have steam coils like the molten sulfur cargo tanks, some have burner tubes and carry propane bottles to fuel the burners.
- The tanks are required to be marked on each side and each end with the word “HOT” in black or white lettering on a contrasting background.
- (See also the general comments on pages 4-22 and 4-23.)

Cargo Tanks (continued)

Van Trailers and Trucks

Hazardous materials are often transported in nonbulk or bulk containers inside van trailers or trucks.



Source: Union Pacific Railroad

- Trailers and trucks may or may not be placarded, depending on the hazardous material and the quantity being transported.
- Even when a placard is required, there is no guarantee that the shipper or driver applied the placards or applied the correct placards. Assume that any van trailer or truck is transporting hazardous materials until proven otherwise.
- Van trailers and trucks might carry a mixed load of different chemicals. Check the shipping papers carefully.
- The contents of a trailer or truck can change over the course of a driver's route. The driver might deliver a partial load to a facility and pick up other materials or empty containers before going to the next destination. Always check with the driver to confirm that the shipping papers are accurate.
- It can be difficult to determine which container is leaking or how many containers are leaking because of the way they are arranged in the trailer or truck.
- (See also the general comments on pages 4-22 and 4-23.)

Delivery Trucks

Hazardous materials are sometimes transported in ordinary delivery trucks. These shipments may or may not be in compliance with 49 CFR. However, the trucks are not placarded. Often the driver does not know what he or she is carrying. There may be no shipping papers to indicate the presence of hazardous materials. This is where you need to be especially alert to clues that something isn't right. When in doubt, assume the worst and err on the side of safety. Request a trained hazmat team to manage the incident and identify the product(s) involved.

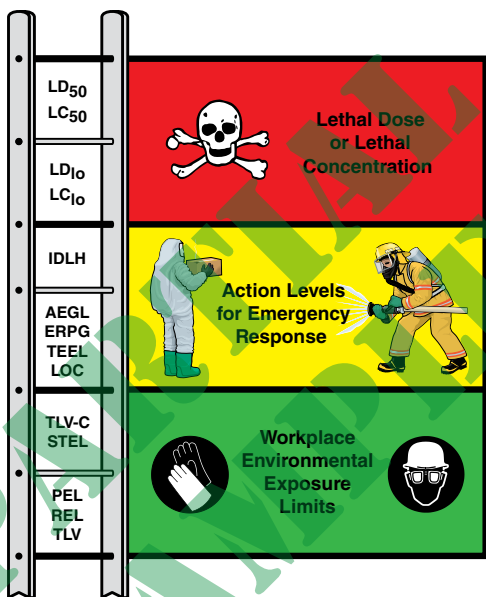
Assessing the Hazards



This chapter is designed to help you assess the hazards at a hazmat or WMD incident. This chapter provides information on ways in which hazardous materials cause harm, toxicity and risk, toxicological terms, occupational exposure limits, properties of flammable liquids, other chemical and physical properties, and atmospheric monitoring. Finally, it goes over special concerns, such as high-risk situations, illicit laboratories, and hazmat triage.

Exposure Values Compared

Because the exposure values covered on the previous pages can be confusing, it often helps to see them on a “hazard ladder” that shows an approximate relation between them. This is obviously not to scale, but it does provide a quick visual representation of how these values stack up against one another.



A Simple Hazard Ladder Shows the Approximate Relation Between Exposure Values (not to scale)

Unfortunately, there may be times when you can't find all of these values in your reference books, particularly books geared toward workplace exposures. For those occasions, you can estimate IDLH or LOC if you know the TLV-TWA. Remember, however, that these are approximations only.

- LOC is generally defined as 10% of the IDLH or 3 times the TLV-TWA.
- Thus, IDLH is 10 times the LOC or 30 times the TLV-TWA.

Exposure Values Compared (continued)

Odor Threshold

One more value, odor threshold, can *sometimes* be plotted on a hazard ladder. Odor threshold is the lowest concentration of a substance in air that can be smelled. If a substance has an odor threshold, it's helpful to know where it stacks up against the toxicity values. Does the substance have adequate warning properties, alerting people to danger before they can be harmed? Or is it dangerous at concentrations well below the odor threshold?

Of course, some substances have no odor. Others, like chlorine, produce olfactory fatigue. When responders stop smelling chlorine, it's not necessarily because the chlorine has dissipated. It may be because olfactory fatigue has obstructed their ability to detect chlorine by smell alone. Additionally, people vary in their ability to detect odors. For example, at least 25% of the population is genetically unable to smell the bitter almond odor of hydrogen cyanide. So odor threshold is nice to know, but it's far from reliable in judging one's potential exposure.

Properties of Flammable Liquids

Flammable liquids are the most common hazardous materials encountered by emergency response personnel. Understanding the properties of flammable and combustible liquids can help you to predict the degree of danger in a spill.

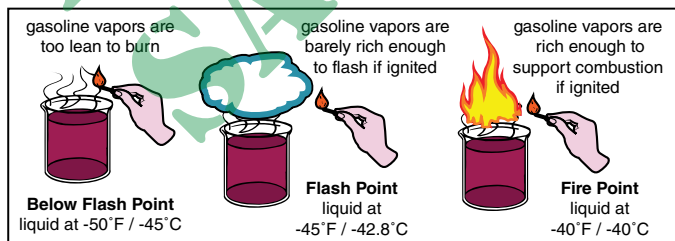
Warning: The word **inflammable** means **flammable**. It does *not* mean *nonflammable*.

Flash Point and Fire Point

Flash point is the minimum temperature at which a liquid produces enough vapor to form an ignitable mixture in air. The vapors may ignite if an ignition source is present. However, the flame does not continue to burn when the source of ignition is removed; rather, the vapors flash and are consumed by the fire. (Flammable gases don't have flash points because they are already in a gaseous state.)

Flash point is generally considered to be the most important temperature in assessing the hazards of flammable and combustible liquids. The lower the flash point, the greater the hazard. (If different sources list different temperatures, assume the worst and err on the side of safety.)

Fire point is the temperature at which enough vapors are given off to support continuous burning after the source of ignition has been removed. It's generally just a few degrees above the flash point.



Flash Point and Fire Point of Gasoline

An important safety measure at any incident where flammable vapors may be present is to eliminate possible ignition sources (e.g., open flames, pilot lights, smoking materials, heated surfaces, electrical sparks, or static electricity) *if you can do so safely*.

Properties of Flammable Liquids (continued)

Ignition (Autoignition) Temperature

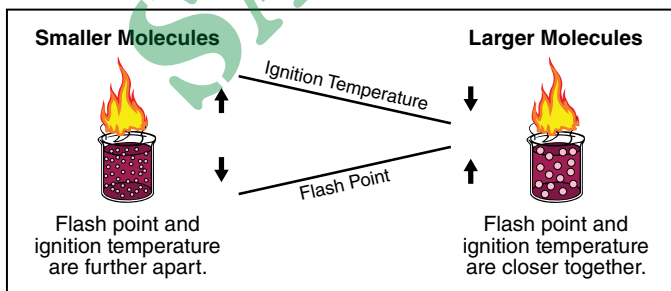
The **ignition (autoignition) temperature** of a substance is the minimum temperature required to cause self-sustained combustion, independent of an ignition source. Simply put, it's the temperature a material must reach before it will ignite. (It's also the temperature the ignition source must be.)

Ignition temperature is sometimes difficult to measure and should be considered an approximation. Ignition comes in two forms:

- **Pilot ignition** involves an external ignition source (e.g., a lit cigarette or a pilot light igniting gasoline vapors).
- **Autoignition** requires only an elevated temperature. In a fire, for example, convection carries hot air and gases to other parts of a building. When the atmosphere becomes hot enough that these gases reach their ignition temperatures, they will ignite without the introduction of any other ignition source. This is called **flashover**.

Effect of Molecular Size on “Like” Compounds

Molecular size directly affects physical and chemical properties. Understanding the relation between these properties can help you predict the hazards of “like” compounds, such as propane (C_3H_8) and octane (C_8H_{18}). In smaller compounds, the flash point and ignition temperature are further apart, while in larger compounds, these properties are closer together.



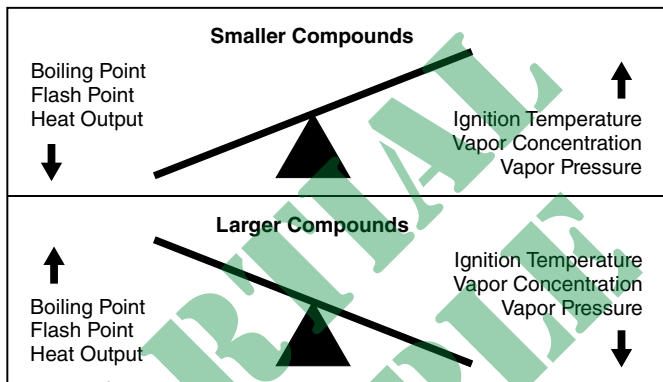
The Relation Between Flash Point and Ignition Temperature

(continued next page)

Properties of Flammable Liquids (continued)

Effect of Molecular Size on “Like” Compounds (continued)

Several properties are directly or indirectly proportional to molecular size. (Again, this assumes one is comparing “like” compounds—ones with similar chemical compositions.)



The Effect of Molecular Size on “Like” Compounds

Smaller compounds are more active than larger compounds are. Thus they vaporize more easily, so less heat is required to reach the flash point or boiling point. Heat output is also lower, because these compounds contain fewer hydrogen atoms (fuel). Because smaller compounds are more active, the vapor pressure and vapor concentration are both higher. Ignition temperature is also higher, because it takes more heat energy to ignite molecules with less hydrogen.

Larger compounds are less active than smaller compounds are. They don't vaporize as easily, so it takes more heat to reach the flash point and boiling point. Heat output is also higher because these compounds contain more hydrogen. Because larger compounds are less active, the vapor pressure and vapor concentration are both lower. However, when an ignitable mixture is produced, the vapors are closer to their ignition temperature; thus it takes less heat to cause ignition.

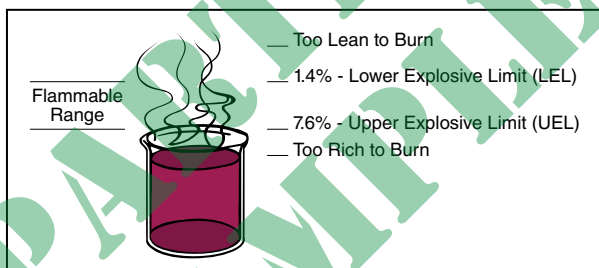
(See pages 5-41 to 5-42 for information on vapor pressure and boiling point.)

Properties of Flammable Liquids (continued)

Flammable (Explosive) Range

Flammable (explosive) range is the percentages of vapor in air within which ignition is possible. Below the **lower explosive limit (LEL)**, the vapors are too lean to burn, whereas above the **upper explosive limit (UEL)**, the vapors are too rich to burn. Sometimes you will see the terms *lower flammable limit (LFL)* and *upper flammable limit (UFL)* instead. They mean the same thing as lower and upper explosive limits.

The wider the flammable range, the greater the span at which ignition is possible and the greater the potential risk. Conversely, products with narrower flammable ranges will present less of a fire hazard. Gasoline, for instance, has a relatively narrow flammable range (1.4% to 7.6%). Compare that, for example, to methyl alcohol (6% to 36%) or acetylene (2.5% to 100%).



The Flammable Range of Gasoline

The lower the LEL, the greater the risk. For example, hydrogen (4% to 75%) reaches its LEL before carbon monoxide (12.5% to 74%) does.

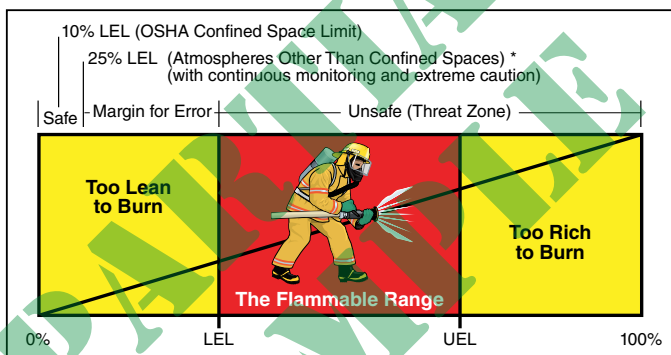
Other factors, like flash point and vapor pressure, also affect the overall flammability risk. However, all things being equal, the greater the flammable range and the lower the LEL, the greater the fire danger. (When different sources list different LEL and UEL values, assume the worst and err on the side of safety.)

(continued next page)

Properties of Flammable Liquids (continued)

Flammable (Explosive) Range (continued)

Only atmospheres that are well below the LEL are safe to enter. Consequently, many response agencies have SOPs or SOGs that prohibit working in an atmosphere greater than 10% of the LEL. (That's 10% of the LEL, not a 10% contaminant concentration in the atmosphere.) In part, this comes from OSHA regulations that prohibit working in *confined spaces* with more than 10% of the LEL. However, when the environment does not meet the definition of a confined space, it may be acceptable for responders to keep working up to 25% of the LEL if they use continuous monitoring and extreme caution.*



Flammable Range

* The 25% guideline comes from the 1985 DHHS (NIOSH) Publication No. 85-115 prepared jointly by NIOSH, OSHA, USCG, and EPA. However, it is a general guideline only, developed with hazardous waste sites in mind, and must not be used as a substitute for department SOPs or SOGs, more specific information from appropriate reference sources, or more recent federal, state, and local regulations. It is essential to leave a good margin of error to guard against fluctuations in the chemical concentration, delays in meter response time (lag time), defective monitors, errors in interpreting the meter readings, and other concerns. When in doubt, use the 10% LEL limit.

Although vapors are too rich to burn *above* the UEL, never consider that to be a safe atmosphere, since vapor concentration may drop to within the flammable range during emergency operations.

Properties of Flammable Liquids (continued)

The Effect of Temperature

A combustible liquid will be below its flash point at normal temperatures. The combustible liquid is relatively safe because it does not generate an ignitable mixture of vapors. However, on a hot day or in a hot environment, a combustible liquid may easily reach its flash point. Both flammable and combustible liquids will be much easier to ignite when the temperature is elevated.

Spontaneous Combustion

A few substances are subject to **spontaneous combustion**. Animal and vegetable oils (e.g., mink oil or linseed oil) are good examples. The oil will slowly oxidize when exposed to air, generating heat in the process. If the heat cannot dissipate fast enough, it will accelerate the production of flammable vapors, then spontaneously ignite those vapors. This is why oily rags left lying in a pile are a fire hazard. Oil-soaked rags should be either kept in tightly closed metal containers that exclude air or hung outdoors (e.g., on a clothesline) where air movement would prevent the buildup of heat.

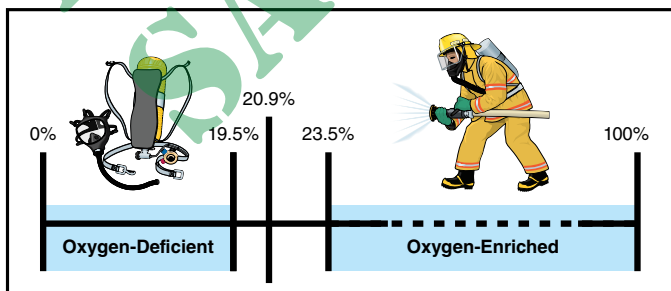
Tools for Comparing Three Primary Threats

We often evaluate hazmat incidents in terms of three primary threats: oxygen deficiency, toxicity, and flammability. To some extent, this is an oversimplification. All the information in this chapter proves that there are many more factors to consider. However, the tools provided on the following pages can help you compare these three threats to see where the greatest risk is. They can also be modified as needed to show other factors.

Review of the Three Primary Threats

The normal atmosphere contains roughly 20.9% oxygen. If the oxygen level is above 23.5% (oxygen-enriched), the atmosphere is considered potentially explosive. (This can be evaluated as part of the flammability question.)

Oxygen Deficiency: What are the potential risks if the atmosphere is oxygen-deficient? An oxygen concentration of 19.5% is considered by OSHA and NIOSH to be the minimum safe level. Below that, the atmosphere is oxygen-deficient and responders must wear self-contained breathing apparatus (SCBA) or supplied air respirators (SAR). Air purifying respirators (APR) are not acceptable, even if they are capable of filtering the specific contaminants in the atmosphere, because they don't provide responders with a source of oxygen.



Oxygen-Enriched and Oxygen-Deficient Threat Zones

(continued next page)

Tools for Comparing Three Primary Threats (continued)

Review of the Three Primary Threats (continued)

An atmosphere with less than 19.5% oxygen is not an immediate threat to life. There's still a margin of safety. However, oxygen deficiency does impair mental and physical abilities, including the ability to recognize and escape from potentially hazardous situations.

Oxygen Level	Effects of Oxygen Deficiency
20.9%	<i>normal concentration</i>
19.5%	<i>minimum safe level per OSHA and NIOSH, but doesn't address possible contaminant concentration</i>
↓	increasing impairment to breathing, coordination, perception, and judgment
6%	difficulty breathing, convulsions, death in minutes

Any oxygen displacement is also an indication that there may be a contaminant present in the atmosphere. Since oxygen comprises roughly one fifth (1/5) of the normal atmosphere, a 1% displacement (from 20.9% to 19.9% oxygen) means there is roughly a 5% concentration of a contaminant gas or vapor.

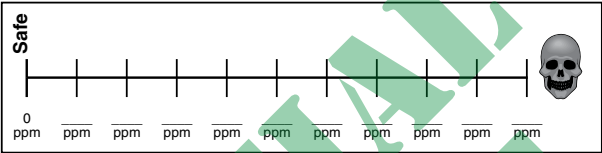
Flammability: If the contaminant is flammable, how close is it to its flammable range? And what is its flash point? (See pages 5-23, 5-26 and 5-27 for explanations of flash point and flammable range.)

Toxicity: If the contaminant is toxic (or otherwise hazardous to health), how does the concentration compare to known exposure limits and toxicity values? (See pages 5-13 to 5-21 for explanations of the terms.) Equally important, what limit gives you the data you need to assess risk? It changes based on the circumstances. For example, to distinguish between a rescue and a body recovery operation, you probably want to use IDLH. To assess the need for protective actions, you might want to use one of the protective action criteria (AEGL, ERPG, or TEEL).

Tools for Comparing Three Primary Threats (continued)

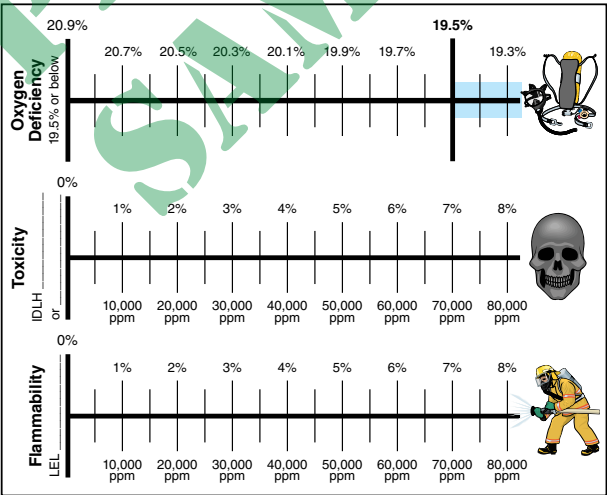
Hazard Ladders

Hazard ladders can help you visualize the threats. Determine a scale appropriate for the material in question. For highly toxic materials, you might use 0 to 0.10 ppm. For others, you might want to go from 0 to 100 ppm or 0 to 1000 ppm. Then plug in exposure limits, toxicity values, and meter readings as appropriate.



A Simple Hazard Ladder to Plot Toxicity

Hazard ladders can be customized as needed. For example, you can draw one from 0% to 100% to plot flammable range and a different one to plot flash point, ignition temperature, and ambient temperature. The illustration below allows you to see the relation between oxygen deficiency, toxicity, and flammability (flammable range). Which threat will you encounter first?



Three Parallel Hazard Ladders

Tools for Comparing Three Primary Threats (continued)

Decision Matrices

Looking only at numbers on a hazard ladder can be misleading. You must also identify your escape window if something goes wrong. An LEL atmosphere presents an immediate risk if vapors ignite. An IDLH atmosphere provides an escape window of up to 30 minutes, although immediate exit is encouraged. An oxygen-deficient atmosphere has an extended escape window with a good safety margin at the OSHA limit of 19.5%.



Flammability (LEL)
immediate risk if vapors ignite

Toxicity (IDLH)
escape window up to 30 minutes, although immediate exit is encouraged

Oxygen Deficiency (<19.5%)
extended escape window with no escape-impairing symptoms at OSHA limit of 19.5%

The Impact of Time on Three Threats

A simple decision matrix that weighs probability of risk against potential consequences is another good tool that can be easily adapted to evaluate the dangers associated with flammability, toxicity, and oxygen deficiency.

Consequences	High	1	2
	Low	0	1
		Low	High
		Probability of Risk	

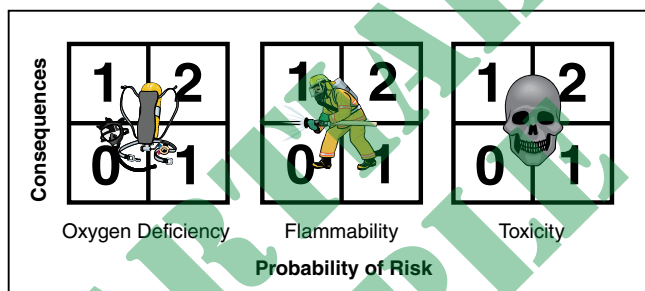
A Simple Decision Matrix That Can Be Easily Adapted

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Tools for Comparing Three Primary Threats (continued)

Decision Matrices (continued)

The text below gives examples of how to use decision matrices to evaluate flammability, toxicity, and oxygen deficiency. However, you can easily customize them by changing the criteria to fit the needs of the incident. Consider, too, individual objectives. Your criteria for protecting emergency responders engaged in mitigation efforts may differ from those for protecting the public.



Decision Matrices Modified for Hazmat Incidents

Oxygen Deficiency: On the probability side, what is the likelihood of reaching an oxygen-deficient atmosphere: low or high? On the consequence side, are responders (or the public) adequately protected: yes or no? Based on your answers, score oxygen-deficiency at 0, 1, or 2.

Flammability: On the probability side, what is the likelihood of reaching a flammable atmosphere: low or high? On the consequence side, are you able to eliminate all ignition sources: yes or no? Based on your answers, score flammability at 0, 1, or 2.

Toxicity: This category is the most variable, because there are so many things you can measure. First determine your objective, then place the right question on the probability side. What is the probability of reaching an IDLH atmosphere? or a protective action limit? or a workplace exposure limit? On the consequence side, are responders (or the public) adequately protected: yes or no? Based on your answers, score toxicity at 0, 1, or 2.

High-Risk Situations

The following situations can be extremely hazardous. Some are dangerous enough that even trained hazmat teams must call for additional assistance. Unless you have the specific training and protective equipment required to handle high-risk situations, leave them for someone with more training and experience.

- **Explosives or explosively unstable chemicals.** Examples include crystallized picric acid, peroxidized ethers from clandestine drug labs, or old dynamite. Do not move or touch these materials. Call for assistance from personnel trained in explosives disposal.
- **Explosive atmospheres.** Potentially explosive conditions exist when a product is at or near its flammable range or when the atmosphere is oxygen-enriched (>23.5% oxygen). It may be possible to manage these conditions by remote product control, foam or water application, or ventilation.
- **Oxygen-deficient atmospheres.** Atmospheres containing less than 19.5% oxygen require the use of SCBA or supplied-air respirators. Keep in mind that any drop in the oxygen level, even a small one, could mean that oxygen was displaced by dangerous levels of a toxic contaminant. Further monitoring may be required.
- **Pressure vessels.** A release from a pressure vessel can cause oxygen displacement. Pressure vessels are also subject to catastrophic failure (BLEVE) when exposed to fire. Call the shipper or CHEMTREC for guidance.
- **Cryogenic materials.** Hazards of a cryogenic release include oxygen displacement and extreme cold (less than -130°F/-90°C). Some cryogenic materials are also extremely flammable or reactive. Cryogenic containers may be subject to catastrophic failure (BLEVE) when exposed to fire. Contact the shipper or CHEMTREC for guidance.
- **Etiologic agents.** Incidents involving infectious materials should be reported to your county health officer and the U.S. Centers for Disease Control and Prevention (CDC).
- **Overpressurized drums.** Overpressurized drums are subject to catastrophic failure when disturbed even slightly. Often they must be opened by remote mechanical devices.
- **Terrorist events.** Terrorist events (WMD incidents) may involve hazardous materials far more dangerous than common household or industrial chemicals. There is also the added risk of possible secondary events aimed at killing or injuring responders.

Nuclear Events



Most of the information in this chapter applies to any incident (intentional or accidental) involving radioactive materials. It includes basic radiation concepts, radiation exposure limits, responder protection guidelines, health effects, patient care, and radiation monitoring. The level of detail provided in this chapter is designed to help dispel some of the myths and concerns that make radiation incidents frightening to so many people.

Note: This book uses the English units of measure (roentgen, rad, and rem), because they are more common in the United States and responders are more familiar with them. Most of the rest of the developed world uses the international (SI) units (gray and sievert). These terms are explained in this chapter, but are not emphasized.

Radiation Exposure Limits (continued)

Incident Stay Time

If you need to enter the hot zone at a radiation incident and you know the dose rate present, you can use the Incident Stay Time Table below to determine how long you can be in the area without exceeding the EPA limits (which are based on hour-long exposures). For example, if you needed to rescue someone who was hurt or trapped in a 50-R/hr atmosphere, you could stay up to 30 minutes without going over the 25-rem limit to save a life. Or you could use multiple teams, limiting each to 12 minutes to keep everyone's exposure at or below 10 rems.

Dose Rate	Time to Receive Maximum Dose		
	5 rem	10 rem	25 rem
2 mR/hr	104 days	208 days	520 days
5 mR/hr	41.6 days	83.3 days	208 days
10 mR/hr	20.8 days	41.6 days	104 days
25 mR/hr	8.3 days	16.6 days	41.6 days
50 mR/hr	4.1 days	8.3 days	20.8 days
0.5 R/hr	10 hours	20 hours	50 hours
1 R/hr	5 hours	10 hours	25 hours
20 R/hr	15 minutes	30 minutes	75 minutes
50 R/hr	6 minutes	12 minutes	30 minutes
100 R/hr	3 minutes	6 minutes	15 minutes

Incident Stay Time Table

You can also calculate stay time with any of the equations below. To understand where the "constant" comes from, multiply 60 (as in minutes) by the appropriate EPA exposure limit. For example, for lifesaving operations (25-rem limit), you can spend 60 minutes in a 25-R/hr atmosphere ($60 \times 25 = 1500$). Exposure rate and time may vary, but the number 1500 is a constant. For protecting valuable property (10-rem limit), the constant is 600 ($60 \times 10 = 600$). For anything else (5-rem limit), the constant is 300 ($60 \times 5 = 300$).

EPA Limit	Constant	Meter Reading	Stay Time
25 rems ...	$1500 \div$	___ R/hr	= ___ Minutes
10 rems ...	$600 \div$	___ R/hr	= ___ Minutes
5 rems ...	$300 \div$	___ R/hr	= ___ Minutes

Time, Distance, and Shielding

The same principles of time, distance, and shielding that protect responders from radiation apply to *any* incident. Therefore, those basic concepts were covered on pages 2-45 and 2-46. However, the following are some other points specific to radiation.

These principles are designed to protect you from internal and external radiation. However, if you've had an internal exposure, your body remains exposed until that radionuclide is eliminated from the body or decays to a stable isotope. Alpha and beta emitters are the most hazardous because alpha and beta particles can transfer ionizing energy to surrounding tissue.

Time

The correlation between *dose* (exposure) and *dose rate* (radiation present in the atmosphere) is directly related to *time*. *Dose rate* is expressed in roentgens *per hour* (R/hr), so the *dose* must be calculated by the hours, or fraction thereof, that one is exposed.

Dose Rate: 50 R/hr	Dose Rate: 50 R/hr
	
Exposure: 25 rems	Exposure: 10 rems

The Relation Between Dose Rate and Dose

- Keep your exposure time to a minimum.
- Establish clear objectives before entering the hot zone.
- Plan your activities carefully so they can be completed as quickly and safely as possible.
- If you know the dose rate present in the atmosphere, use the incident stay time table or the equation provided on page 11-10 to calculate mission duration.
- If you don't know the dose rate, be expeditious, but not so hasty that you cause harm. For instance, you can take time to safely extricate a patient, but don't linger in the hot zone afterwards.
- If operations in the hot zone will be extended, rotate personnel through the area to limit individual exposure.

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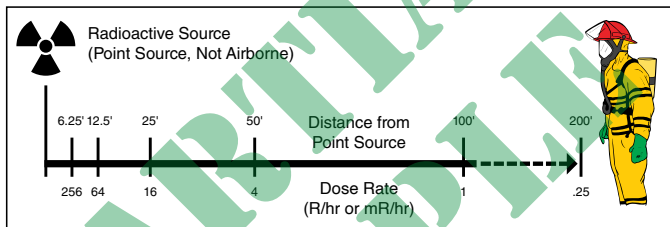
Time, Distance, and Shielding (continued)

Time (continued)

- Assign a timekeeper to track personnel in the hot zone.
- Limit patient care in the hot zone to maintaining an airway, controlling severe bleeding, and immobilizing the spine.

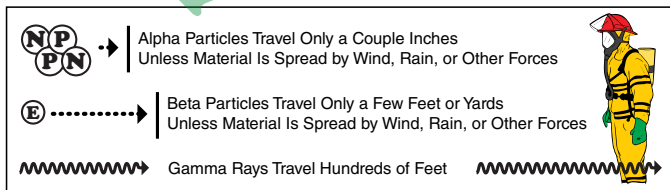
Distance

Distance is a more important factor than time is in controlling exposure. Whereas cutting exposure time in half cuts the dose in half, doubling your distance from the radioactive source reduces the exposure by 75%. This is known as the *Inverse Square Law*. Note: This applies to a point source, not an airborne source.



Doubling Your Distance Reduces Your Exposure by 75%.

Distance is also effective in reducing the type of exposure. Alpha particles travel only a couple inches in air. Beta particles travel several feet to several yards. Unless you have the contaminant on you or the material is being spread by wind, rain, or other forces, once you back out of the area, you are no longer at risk from alpha and beta particles; you need worry only about gamma radiation.



Distance Helps Control Type of Exposure Too

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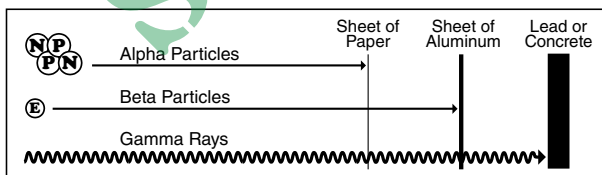
Time, Distance, and Shielding (continued)

Distance (continued)

- Stay upwind, uphill, and upstream to protect against airborne particles.
- Use remote devices whenever possible. For example, use unmanned monitors instead of hand lines to fight a fire.
- Use the current edition of the ERG to determine appropriate isolation and evacuation distances. Guides 161 through 165 in the ERG recommend 75 feet (25 meters) for initial isolation, 330 feet (100 meters) for downwind evacuation on a large spill, and 1000 feet (300 meters) for initial evacuation when a large quantity of radioactive material is involved in a major fire.
- Confirm safe distances by monitoring the atmosphere.
- Use common sense when establishing isolation zones. It's appropriate to err on the side of safety if you are unsure of the risks. However, incidents involving dangerous levels of radiation are rare, and releases are uncommon, even under accident conditions, due to the sturdy packaging. So, seldom is it necessary, for example, to shut down a freeway in both directions, severely impacting the entire community.

Shielding

Appropriate shielding will help reduce your exposure. Alpha particles are stopped by shielding as thin as a sheet of paper. It takes heavier shielding, such as a thick piece of aluminum or an inch of wood, to stop beta radiation. Gamma radiation is so penetrating that far denser shielding, such as several inches of lead or concrete, is required.



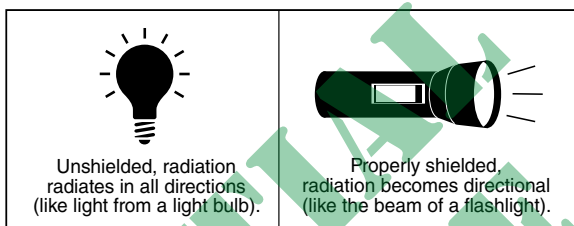
The Effect of Shielding on Alpha, Beta, and Gamma Radiation

(continued next page)

Time, Distance, and Shielding (continued)

Shielding (continued)

Radiation can be directional, like the beam of a flashlight. If a package is breached, but the radioactive source is still contained within the package, radiation will be projected in the direction of the breach. Any radiation detected in another direction should be within normal limits of what is permissible at the surface of the package and from 1 meter (3 feet) away.



The Effect of Shielding on Radiation Direction

Radioactive materials and wastes are placed in different types of packages based on level of radioactivity. (See page 4-15.) The packages not only provide shielding but also allow you to make a quick estimate about the degree of risk posed by the radioisotope and the likelihood of a breach based on severity of impact in an accident. Type B and C packages are the only ones that contain potentially life-endangering amounts of radioactive materials. (Package type should be identified on the container and on shipping papers.)

- Wear proper PPE. (See next page.)
- Use any other available shielding. Lead is the best shield against gamma rays and x-rays, but it's generally not practical for emergency operations. However, you can position yourself behind fire engines, buildings, or hills when not directly involved in hot zone operations.
- Even when working in the hot zone, you can use available shielding, such as approaching from behind vehicles versus moving in direct line of sight.
- If appropriate, minimize dispersal of radioactive materials (e.g., by wind and rain) by covering them with a tarp, a plastic sheet, or even dirt.

Time, Distance, and Shielding (continued)

Protective Clothing As Shielding

Personal protective equipment (PPE) also provides some shielding. Firefighters should wear structural firefighting clothing and SCBA to enter the hot zone. This provides full protection from alpha particles. It also protects against inhalation or ingestion of beta particles. Although some beta radiation may penetrate protective clothing, the clothing does reduce the exposure potential. (Again, one can use the flashlight analogy. Light from a flashlight will penetrate clothing, but it will be less strong on the other side.) Structural firefighting clothing will not protect against penetrating radiation such as gamma rays and neutron particles.

EMS personnel do not need special protective clothing if patients have been thoroughly decontaminated. However, if that is not the case, EMS personnel should, if possible, wear a long-sleeve uniform, gloves, hood or hair cover, eye protection, shoe covers, and a face mask (e.g., an N95 HEPA filter mask or equivalent). The clothing will protect against inhalation, ingestion, and secondary contamination (skin contact) with alpha and beta emitters. It will not protect against radiation penetration. The best protection for that is to ensure that contaminated patients are thoroughly decontaminated once more serious injuries are cared for.

Police officers and other personnel who don't enter the hot zone also need no special protective clothing. However, anyone who must handle contaminated people or evidence should wear a long-sleeve uniform, gloves, hood or hair cover, eye protection, shoe covers, and a face mask (e.g., an N95 HEPA filter mask or equivalent). The clothing will protect against inhalation, ingestion, and secondary contamination (skin contact) with alpha and beta emitters. It will not protect against radiation penetration.

As soon as practical, responders should remove outer garments that might have become contaminated. They should then be monitored to determine if further clothing removal or decon is needed.

Index

Topic	Page(s)
29 CFR 1910.120	xxiii, 2-43
About the Author	15-36
Acknowledgments	xv – xx
Acronyms and Abbreviations	xxiv – xxix
Acute Exposure Guideline Levels (A EGL)	5-16 – 5-17, 5-21
Agency for Toxic Substances and Disease Registry	14-29
Agricultural Chemicals and Pesticide Labels	3-34
Agricultural Department	14-52
Aircraft	4-56
Air Ambulances	6-30
Air Purifying Respirators (APR)	2-49
Air Reactivity	5-35
Air Traffic Control Center	14-45
Amateur Radio Operators	14-19
Animal Rescue Groups	14-56
Animal Resources	14-55 – 14-57
Ambulance Preparation	6-9
Antidotes	6-29
ASPCA Animal Poison Control Center	14-55
Asphyxiation Hazards	5-5
Assessing the Hazards	Chapter 5
Assume Command	2-12 – 2-19
Atmospheric Monitoring	5-48 – 5-50
Author's Commentary - Secondary Contamination	6-4 – 6-7
Awareness Level Personnel (Duties of)	1-3
Barges and Ships	4-57
Bibliography	15-3 – 15-19
Biological Warfare Agents	Chapter 10
Anthrax	10-20 – 10-21
Botulism	10-22
Brucellosis	10-23
CDC Bioterrorism Agent Categories	10-4 – 10-5
Cholera	10-24
Decon (Patient and Equipment)	10-11
Detection	10-12 – 10-13
Distinguishing from Chemical Agents	7-6 – 7-7
E. coli	10-25
Glanders	10-26
Health Effects (General)	10-8

Index (continued)

Melioidosis	10-27
Personal Protective Equipment	10-9 – 10-11
Plague	10-28
Q Fever	10-29
Rate of Action (Incubation Period)	10-7
Ricin	10-30
Routes of Exposure / Dissemination	10-6 – 10-7
Salmonellosis	10-31
Saxitoxin	10-32
Smallpox	10-33 – 10-34
Staphylococcal Enterotoxin B (SEB)	10-35
Treatment (General)	10-12
Trichothecene Mycotoxins	10-36
Tularemia	10-37
Types of Biological Agents	10-3
Venezuelan Equine Encephalitis (VEE)	10-38
Viral Hemorrhagic Fevers (VHF)	10-39
White Powder Calls	10-14 – 10-19
Characteristics of Suspicious Mail	10-14
General Guidelines: Handling and Opening Mail	10-15
Recipient Guidelines: Suspicious Mail	10-15
Responder Guidelines: Suspicious Mail	10-17 – 10-19
Threat Credibility Assessment	10-16
BLEVE	3-9, 5-34
Blister Agents (Vesicants)	9-17 – 9-21
Blood Agents	9-22 – 9-24
Body Substance Isolation Procedures	6-8
Boiling Point	5-34, 5-42
Bulk Packaging	4-13 – 4-15
Bulk Bags	4-13
Nonpressure Portable Tanks	4-14
Portable Bins	4-13
Radioactive Protective Overpacks and Casks	4-15
Ton Containers (One Tons)	4-14
Bureau of Alcohol, Tobacco and Firearms (ATF)	14-51
Bureau of Explosives	14-44
Canadian Transport Emergency Center (CANUTEC)	14-41
Carcinogens, Mutagens and Teratogens	5-8

Index (continued)

Cargo Tanks	4-22 – 4-32
Asphalt Trailers	4-31
Atmospheric-Pressure (MC-306/DOT-406)	4-24
Compressed Gas Trailer (Tube Trailer)	4-30
Corrosive Liquid (MC-312/DOT-412)	4-26
Cryogenic Liquid (MC-338)	4-28 – 4-29
Delivery Trucks	4-32
Gasoline Tankers	4-23
General Incident Considerations	4-23
Low-Pressure (MC-307/DOT-407)	4-25
Molten Sulfur	4-31
Pneumatically Offloaded (Dry Bulk) Hoppers	4-30
Pressure (MC-331)	4-27
Tank Markings	4-22
Van Trailers and Trucks	4-32
CDC Bioterrorism Agent Categories	10-4 – 10-5
Centers for Disease Control and Prevention (CDC)	14-28
Chemical and Physical Change	5-34 – 5-38
Chemical and Physical Properties	5-39 – 5-47
Chemical Asphyxiants	6-23
Chemical Incompatibility	5-38
Chemical Protective Clothing	2-51, 2-53 – 2-54
Chemical Reactivity	5-35
Chemical Safety and Hazard Investigation Board (CSB)	14-54
Chemical Warfare Agents	Chapter 9
Blister Agents (Vesicants)	9-17 – 9-21
Blood Agents	9-22 – 9-24
Choking Agents	9-25 – 9-27
Detection	9-9 – 9-12
Distinguishing from Biological Agents	7-6 – 7-7
Health Effects (Overview)	9-4
Nerve Agents	9-13 – 9-16
Patient Decon	6-10 – 6-15, 9-5
Personal Protective Equipment	9-7 – 9-8
Properties That Affect Risk	9-6
Rescue Considerations	2-36 – 2-40
Riot Control Agents	9-28 – 9-30
Routes of Exposure / Dissemination	9-5
Types of Chemical Agents (Overview)	9-3
CHEMTREC	14-40
Children	13-21 – 13-22
Choking Agents	9-25 – 9-27

Index (continued)

Clandestine Drug Labs	5-52 – 5-57
Cleanup and Disposal	2-62
Coast Guard (USCG)	14-43
Cold Emergencies	6-37 – 6-39
Cold (Support) Zone	2-21
Collect Hazard Information	2-27 – 2-28
Combustible Liquids	3-12
Communications / Dispatch	14-19
Community Emergency Response Teams (CERT)	14-20
Comparing Three Primary Threats	5-29 – 5-33
Confined Spaces	5-27
Container Recognition	Chapter 4
Aircraft	4-56
Bulk Packaging	4-13 – 4-15
Cargo Tanks	4-22 – 4-32
Container Failure	4-4
Facility Containers	4-45 – 4-54
General Safety Considerations	4-3
Intermodal Tanks	4-16 – 4-21
Nonbulk Packaging	4-5 – 4-12
Pipelines	4-58
Rail Cars	4-33 – 4-44
Ships and Barges	4-57
Contamination Versus Exposure	5-13, 11-16
Contractors	14-22
Control Zones	2-21
Coroners / Medical Examiners	14-23
Corrosive Hazards	5-5
Corrosives	3-17, 6-21 – 6-21
Corrosivity	5-46 – 5-47
Critique	2-64
Cryogenic Liquids	3-10
Dangerous When Wet Materials	3-13
Dangerous Placard	3-7
Dead, Handling of	6-31
Debriefing	2-63
Decision Matrices	5-32 – 5-33
Decontamination	2-57 – 2-60, 6-10 – 6-15, 12-20 – 12-22
Decon Solutions	2-59, 6-12 – 6-13
Equipment Decon	2-59
General Decon Considerations	2-57
Locating the Decon Station	2-58

Index (continued)

Patient Decon	6-10 – 6-15
Priorities	6-11
Response Vehicle Decon	2-60
Technical Decon	2-60, 12-20 – 12-22
Department of Defense (DOD)	14-46
Department of Energy (DOE)	14-53
Department of Homeland Security (DHS)	14-39
Department of the Interior (DOI)	14-52
Department of Transportation (DOT)	14-43
Detection of Biological Warfare Agents	10-12 – 10-13
Detection of Chemical Warfare Agents	9-9 – 9-12
Dirty Bomb	11-31
Disaster Medical Assistance Teams (DMAT)	14-30
Disaster Relief Agencies	14-23
Disclaimer	xxx
Dispatch / Communications	14-19
Documentation	2-65 – 2-66, 13-19
DOT Placards and Labels	3-3 – 3-19
4-Digit Identification Number	3-4
Dangerous Placards	3-7
Limitations	3-6
Placards with Square White Backgrounds	3-5
Subsidiary Hazard Placards	3-4
Table 1 and Table 2 Commodities	3-7
Older Placards and Labels	3-5
DOT Hazard Classes	3-3 – 3-19
Corrosive Materials	3-17
Dangerous When Wet Materials	3-13
Explosives (and Blasting Agents)	3-8, Chapter 8
Flammable and Combustible Liquids	3-11 – 3-12
Flammable Solids	3-13
Gases	3-9 – 3-10
Miscellaneous Hazardous Materials	3-18
ORM-D Materials	3-19
Oxidizers and Organic Peroxides	3-14
Poisonous and Infectious Substances	3-15
Radioactive Materials	3-16, Chapter 11
Rescue Considerations Based On	2-37
Spontaneously Combustible Materials	3-13
Drug Labs	5-52 – 5-57
Drugs and Antidotes	6-29
Drug Enforcement Administration (DEA)	14-51

Index (continued)

Emergency Alert System	13-3
Emergency (Patient) Decon	6-10 – 6-15
Emergency Management Agency (EMA)	14-49
Emergency Medical Services (EMS)	14-17
Emergency Operations Center (EOC)	14-18
Emergency Procedures/Communications	2-35, 2-66
<i>Emergency Response Guidebook</i>	14-6 – 14-11
Emergency Response Networks	14-50
Emergency Response Planning Guideline	5-16 – 5-18, 5-21
Emergency Shelters	13-11 – 13-12
Emergency Transport System (SETIQ) (Mexico)	14-41
EMS Responders	xxii, 1-7 – 1-8, 2-25
EMS Equipment and Supplies	6-32
EMS Records	2-66
EMS Treatment Protocols	6-26 – 6-29
Advanced Life Support	6-28
Basic Life Support	6-27 – 6-28
Drugs and Antidotes	6-29
Patient Assessment	6-26
Environmental Protection Agency (EPA)	14-50
Equipment Decon	2-59
Estimate the Potential Outcome	2-31
Etiological Hazards	5-7
Evacuation	2-55, 13-10 – 13-14
Evacuation Distances	2-7 – 2-9, 2-56
Evaluate Your Progress	2-61
Evidence	13-16 – 13-20
Excepted Quantities	3-19
Explosives	3-8, Chapter 8
After Detonation of an Explosive	8-23
Background Information	8-3 – 8-5
Classification of Explosives	8-3 – 8-4
Effects of an Explosion	8-5
Explosive Devices	8-8 – 8-10
Acid Bombs	8-10
Dry Ice Bombs	8-10
Grenades	8-9
Mail Bombs	8-8
Pipe Bombs	8-9
Explosive Trains	8-4

Index (continued)

Explosives	8-11 – 8-16
Ammonium Nitrate	8-16
Black Powder	8-14
Blasting Agents	3-8, 8-16
Boosters	8-15
Composition C-4	8-13
Dynamite	8-11
Other Primary Explosives	8-16
Sheet Explosives	8-13
Smokeless Powder	8-14
TNT (Trinitrotoluene)	8-12
Two-Part (Binary) Explosives	8-12
Fireworks	8-17
Identification of Explosives	8-6 – 8-7
Ignition Devices	8-18 – 8-19
Blasting Caps	8-19
Detonating (Det) Cord	8-18
Fuse Igniters and Improvised Igniters	8-19
Safety Fuse	8-18
Other Clues / Indicators	8-20
Placards	3-8
Types of Explosions	8-3
Upon Discovery of an Explosive	8-21 – 8-22
Exposure Records	2-66
Exposure Values Compared	5-21
Exposure Versus Contamination	5-13, 11-16
Facility Containers	4-45 – 4-54
Atmospheric Fixed-Roof Tanks	4-46
Covered Floating Roof Tanks	4-48
Cryogenic Liquid Tanks	4-52
General Incident Considerations	4-45
High-Pressure Horizontal Tanks	4-50
High-Pressure Spherical Tanks	4-51
Low-Pressure Horizontal Tanks	4-49
Open-Top Floating Roof Tanks	4-47
Piping Systems	4-54
Spheroid and Noded Spheroid Tanks	4-49
Underground Storage Tanks	4-53
Vertical Dome Roof Tanks	4-48
Facility Signage	3-35
Faith-Based Organizations	14-20

Index (continued)

Federal Bureau of Investigation (FBI)	14-51
Federal Emergency Management Agency (FEMA)	14-49
Fire Department	14-16
Fireworks	8-17
Fish & Wildlife Service	14-55
Flammability Risk	5-29 – 5-33
Flammable Liquids	3-11, 5-23 – 5-28
Flammable (Explosive) Range	5-26 – 5-27
Flammable Solids	3-13
Flash Point and Fire Point	5-23, 5-24 – 5-25
Flood District Office	14-21
Foam	12-11 – 12-14
Forestry Department	14-52
Fumigant Marking	3-33
Funding and Disposal Responsibility	2-62
Gases	3-9 – 3-10
Globally Harmonized System (GHS)	3-36 – 3-39
Hazmat Triage	5-58
Hazard Identification Codes	3-22
Hazard Information	2-27 – 2-28
Hazard Ladders	5-31
Hazardous Materials Information System (HMIS®)	3-29 – 3-31
Hazardous Waste Disposal Laws	2-62
Hazmat Group/Branch	2-17 – 2-18
HAZWOPER	xxiii
Health Departments (State and County)	14-28
Heat Emergencies	6-35 – 6-36
High-Risk Situations	5-51
Highway Route Controlled Quantity	3-5, 11-20
Homeland Security, Department of (DHS)	14-39
Hospitals	6-30, 14-27
Hot Warning	3-33
Hot (Exclusion) Zone	2-21
How Hazardous Materials and WMDs Cause Harm	5-3 – 5-7
How to Use this Book	iii - iv
Hydrocarbon Solvents	6-24

Index (continued)

Ignition Temperature	5-24 – 5-25
Illicit Laboratories	5-52 – 5-57
Immediately Dangerous to Life and Health (IDLH)	5-15, 5-21
Implement the Planned Response	2-44 – 2-46
Improvised Nuclear Device (IND)	11-31
In-Place Protection	2-55, 13-13, 13-15
Incident Command Authority	2-18
Incident Commander (Duties of)	1-9 – 1-10, 2-12 – 2-14
Incident Levels	2-26
Incident Command System (ICS)	2-12 – 2-19, 2-44
Industry Resources	14-22
Infectious Substances	3-15
Information Resources	2-28, Chapter 14
Inhalation Hazard Warning	3-33
Initial Isolation Zone	2-20
Intermodal Tanks (UN Portable Tanks)	4-16 – 4-21
Container Markings	4-17 – 4-18
Cryogenic	4-20
General Incident Considerations	4-16
Hazard Identification Codes	3-22
Nonpressure	4-19
Pressure	4-19
Tube Modules	4-21
International Placards and Labels	3-21
Internet Resources	14-59 – 14-69
Introduction and Purpose	xxi – xxiii
Isolate and Deny Entry	2-20 – 2-21
Isolation Distances	2-7 – 2-9, 2-56
Indoor Incidents	2-9
Outdoor Incidents	2-7 – 2-9
Law Enforcement	14-17
Lethal Dose (LD) or Lethal Concentration (LC)	5-14, 5-21
Level of Concern (LOC)	5-15, 5-21
Liability and Negligence	13-6 – 13-7
Licensed Waste Haulers	14-22
Limited and Excepted Quantities	3-19
Make a Safe Approach	2-7 – 2-9
Marine Pollutant Mark	3-33
MARK 1 Autoinjector	9-15 – 9-16
Materials of Trade (MOTs)	3-20
Mechanical Hazards	5-4

Index (continued)

Media	13-3 – 13-5, 14-26
Medical Component of the Incident Command System	2-19
Medical Examiners / Coroners	14-23
Medical Management of Hazmat Exposures	Chapter 6
Ambulance Preparation	6-9
Body Substance Isolation Procedures	6-8
Common Signs and Symptoms of Exposure	6-21 – 6-25
Coordination with Other Medical Providers	6-30
EMS Treatment Protocols	6-26 – 6-29
Heat and Cold Emergencies	6-35 – 6-39
Medical Centers and Supply Caches	14-32
Medical Support for Hazmat Personnel	6-33 – 6-34
Patient Decon	6-10 – 6-15
Secondary Contamination	6-3 – 6-9
Strategic National Stockpile (SNS)	14-31
Transporting Patients	6-9
Triage	6-16 – 6-20
Universal Precautions	6-8
Medical Support for Hazmat Personnel	6-33 – 6-34
Other Post-Entry Considerations	6-34
Pre- and Post-Entry Exclusion Criteria	6-33
Problems Observed During Entry	6-34
Mental Health Professionals	14-27
Military Markings	3-32
Miscellaneous Hazardous Materials	3-18
Miscibility	5-44 – 5-45
Molecular Size, Effect of	5-24 – 5-25
National Guard	14-47
National Guard WMD Civil Support Teams (CST)	14-48
National Response Center (NRC)	14-34 – 14-38
National Response Team (NRT)	14-34 – 14-35
National Terrorism Advisory System (NTAS)	7-9 – 7-10
National Transportation Safety Board (NTSB)	14-42
National Weather Service	14-54
Negligence and Liability	13-6 – 13-7
Neighboring Agencies / Response Teams	14-18
Nerve Agents	9-13 – 9-16
NFPA 470	xxiii
NFPA 704 Marking System	3-23 – 3-28
National Disaster Medical System (NDMS)	14-30
National Incident Management System (NIMS)	2-12
No-Go Situations	2-34

Index (continued)

Nonbulk Packaging	4-5 – 4-12
Bags	4-6
Bottles	4-6
Boxes	4-7
Carboys	4-8
Cylinders	4-9 – 4-11
Drums	4-12
General Comments	4-5
Jerricans	4-8
Multicell Packaging	4-7
Notification Requirements	2-5, 2-19, 2-20, 14-15, 14-37 – 14-38
Nuclear Events (<i>See also Radiation</i>)	Chapter 11
Nuclear Terrorism Scenarios	11-29 – 11-31
Odor Threshold	5-22
Oil Spills (Reporting Requirements)	14-37
Operations Level Responders (Duties of)	1-4 – 1-6
Oxidizers and Organic Peroxides	3-14
Oxygen Deficiency	5-29 – 5-33
Packing Group Designations	3-34
Patient Decon	6-10 – 6-15
Decon Solutions	6-12 – 6-13
Decon Versus Medical Care	6-11
Emergency Responders	6-15
Eye Contact	6-15
Gases and Vapors	6-13
General Concepts	6-10
Mass Casualties	6-15
Skin Contact	6-14
Permissible Exposure Limit (PEL)	5-19, 5-21
Personal Alert Safety Systems (PASS)	2-52
Personal Protective Equipment (PPE)	2-45, 2-47 – 2-54
for Biological Warfare Agents	10-9 – 10-11
for Chemical Warfare Agents	9-7 – 9-8
for EMS Personnel	6-8
for Radiation Incidents	11-15
Personnel Accountability	2-41
Pesticide Exposures	6-23
Pesticide Labels	3-34
pH Scale for Corrosives	5-46
Physical and Chemical Change	5-34 – 5-38

Index (continued)

Pipe Marking Systems	3-35
Pipeline Markers	3-35
Pipeline Releases (Reporting Requirements)	14-37
Pipelines	4-58
Planning the Initial Response	2-32 – 2-43
Response Options (Tactics)	2-33, 12-3 – 12-10
Equipment and Procedures	2-35
Key Points	2-43
No-Go Situations	2-34
Personnel Accountability	2-41
Pre-Event and Event-Specific Action Planning	13-8 – 13-9
Rescue Considerations	2-36 – 2-40
Response Objectives (Strategy)	2-32
Rest and Rehabilitation	2-42
Safety Briefing	2-44
Poison Control Centers	14-29
Poisonous Hazards	5-4
Poisonous and Infectious Substances	3-15
Polarity	5-44 – 5-45
Police K-9 Units	14-55
Polymerization	3-14, 5-36 – 5-37
Post-Incident Analysis	2-64
Postal Inspection Service	14-51
Pre-Event and Event-Specific Action Planning	13-8 – 13-9
Predict Behavior of Material and Container	2-29 – 2-30
Preface	xiii – xiv
Preservation of Evidence	13-16 – 13-20
Product Control Options	2-30, 12-3 – 12-10, 12-15 – 12-19
Properties of Flammable Liquids	5-23 – 5-28
Protection-in-Place	2-55, 13-13, 13-15
Protective Action Messages	13-13 – 13-15
Protective Action Criteria (PAC)	5-16 – 5-18
Protective Actions	2-55 – 2-56
Public Utilities	14-21
Public Works Department	14-21
Pulmonary Irritants	6-22
Quick Reference Guides	Chapter 1
Awareness Level Personnel	1-3
EMS Responders	1-7 – 1-8
Incident Commander	1-9 – 1-10
Operations Level Responders	1-4 – 1-6

Index (continued)

Radiation	3-16, 5-6, Chapter 11
Background Radiation	11-28
Basic Radiation Concepts	11-3 – 11-6
Exposure Limits	11-9 – 11-10
Exposure Versus Contamination	11-16
Half-Life	11-6
Health Effects	11-16 – 11-18
Incident Stay Time	11-10
Ionizing Radiation	11-3 – 11-4
Measurement	11-7 – 11-8
Monitoring Essentials	11-22 – 11-28
Nuclear Terrorism Scenarios	11-29 – 11-31
Other Hazards of Radioactive Materials	11-6
Package Types	4-15
Patient Decon	11-19
Patient Treatment	11-19
Personal Protective Equipment	11-15
Placards and Labels	3-16, 11-20 – 11-21
Radiation Sickness	5-6, 11-16 – 11-18
Radioactive Materials	3-16, Chapter 11
Time, Distance, and Shielding	11-11 – 11-15
Transport Index (TI)	11-21
Radiological Dispersal Device (RDD) or Dirty Bomb	11-31
Radiological Officer	14-53
Rail Cars	4-33 – 4-44
Box Cars	4-43
Cryogenic Liquid	4-39 – 4-40
General Incident Considerations	4-33
High-Pressure Tube Cars	4-41
Hopper Cars	4-42
Markings	4-34 – 4-35
Multiunit Tank Car Tanks	4-44
Nonpressure (General Service or Low-Pressure)	4-36
Pressure	4-38
Refrigerator Cars	4-43
Tank Train	4-37
Trailers and Containers on Flat Cars	4-44
Railroads (Resources for Assistance)	14-44
Recognize the Presence of Hazardous Materials	2-5
Recommended Exposure Limits (REL)	5-19, 5-21
RedRover	14-56
Rehab	2-42

Index (continued)

Report on Conditions	2-11
Reporting Requirements	14-37 – 14-38
Rescue Considerations	2-36 – 2-40
Resources for Information and Assistance	Chapter 14
Respiratory Protection	2-48 – 2-50, 9-7 – 9-8, 10-9 – 10-11
Response Objectives and Options	2-32 – 2-33
Response Vehicle Decon	2-60
Riot Control Agents	9-28 – 9-30
Routes of Entry	5-9, 9-5, 10-6 – 10-7
Safe Approach	2-7 – 2-9
Safety Briefing	2-44
Safety Data Sheets (SDS)	14-14
Safety Guidelines	2-10
Safety Officer Responsibilities	2-15 – 2-17
SBCCOM Report	2-38 – 2-40
SCBA	2-48
Scene Control Procedures	2-44
School District Superintendents	14-25
Secondary Contamination	6-3 – 6-9
Sewer Department or Sewage Treatment Plant	14-21
Shelter-in-Place	2-55, 13-13, 13-15
Shelters (Emergency)	13-11 – 13-12
Shipping Papers	14-12
Ships and Barges	4-57
Short-Term Exposure Limit (STEL)	5-20, 5-21
Size Up the Incident	2-24 – 2-26
Solubility	5-44 – 5-45
Specific Gravity / Water Solubility	5-44 – 5-45
Spontaneously Combustible Materials	3-13
Spontaneous Combustion	5-28
Standards for Protective Clothing and Equipment	2-53
Strategic National Stockpile (SNS)	14-31
Surrounding Conditions	2-25 – 2-26
Synergistic Effect	5-11
Table I and Table II Commodities	3-7
Table of Contents	v - x
Target Organ Effects	5-10 – 5-11
Technical Decon	12-20 – 12-22
Telephone Companies	14-19
Temporary Emergency Exposure Levels (TEEL)	5-16, 5-18, 5-21
Terminate the Incident	2-63 – 2-64

Index (continued)

Terrorism	Chapters 7 – 11
Biological Warfare Agents	Chapter 10
Chemical Warfare Agents	Chapter 9
Chemical Agents Versus Biological Agents	7-6 – 7-7
Explosives Incidents	Chapter 8
Indications of	7-4 – 7-5
Introduction to Terrorism	Chapter 7
Nuclear Events (Intentional or Accidental)	Chapter 11
Special Concerns with Terrorist Events	7-5
Strategic and Tactical Considerations	7-8
Thermal Hazards	5-3
Threshold Limit Value (TLV)	5-19 – 5-21
Time, Distance, and Shielding	2-45 – 2-46, 11-11 – 11-15
Tools for Comparing Three Primary Threats	5-29 – 5-33
Toxicity and Risk	5-12, 5-29 – 5-33
Toxicological Terms and Exposure Values	5-13 – 5-18, 5-21
Toxicology: Exposure Potential	5-9 – 5-11
Transfer Command/Control	2-64
Transportation Accidents (Reporting Requirements)	14-37 – 14-38
Transporting Patients	6-9
Treatment Protocols	6-26 – 6-29
Advanced Life Support	6-28
Basic Life Support	6-27 – 6-28
Drugs and Antidotes	6-29
Patient Assessment	6-26
Triage	6-16 – 6-20
UN Portable Tanks (Intermodal Tanks)	4-16 – 4-21
Container Markings	4-17 – 4-18
Cryogenic	4-20
General Incident Considerations	4-16
Hazard Identification Codes	3-22
Nonpressure	4-19
Pressure	4-19
Tube Modules	4-21
Unified Command	2-19
Universal Precautions	6-8
Urban Search & Rescue (US&R) Marking System	3-40 – 3-42
Urban Search & Rescue (US&R) Task Force	14-54

Index (continued)

Vapor Density	5-39 – 5-40
Vapor Expansion Ratio	5-43
Vapor Pressure and Volatility	5-41 – 5-42
Vehicle Decon	2-60
Vesicants (Blister Agents)	9-17 – 9-21
Veterinarians	14-57
Warm (Contamination Reduction) Zone	2-21
Water Reactivity	5-36
Water Solubility	5-44 – 5-45
Web Sites of Interest	14-59 – 14-69
White Powder Calls	10-14 – 10-19
Characteristics of Suspicious Mail	10-14
General Guidelines: Handling and Opening Mail	10-15
Recipient Guidelines: Suspicious Mail	10-15
Responder Guidelines: Suspicious Mail	10-17 – 10-19
Threat Credibility Assessment	10-16
Workplace Environmental Exposure Limits (WEEL)	5-19 – 5-21
WMD Civil Support Teams	14-48

About the Author

Jill Meryl Levy owns her own business called Firebelle Productions. She is an author and publisher, specializing in books on hazardous materials and more effective writing. She is also now a paralegal working for the Abronson Law Offices.

Jill has worked in the field of safety education since 1981 when she was hired by the City of Santa Clara Fire Department in California. Later, during her employment at Hewlett-Packard Company in Cupertino, California, Jill began producing brochures, booklets, and newsletters as a means to communicate safety information to a large employee population. The publications became so popular that she was soon producing brochures and booklets on a corporate-wide basis.

Jill first got involved with hazardous materials while working with the Governor's Office of Emergency Services California Specialized Training Institute (CSTI) on the 1994 and 1995 revisions of its Hazardous Materials Technician/Specialist curriculum. In 1995 she became a CSTI-certified hazardous materials specialist and a first responder outreach instructor. Jill has also assisted the California State Fire Marshal's Office with curriculum revision projects.

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Books by Jill Meryl Levy

- The First Responder's Field Guide to Hazmat & Terrorism Emergency Response
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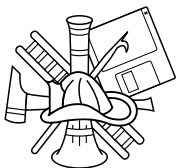
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