Hazardous Materials for First Responders

5th Edition

Chapter 1 - **Introduction to Hazardous Materials**

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This presentation is an ***overview*** of the 5th Edition, Hazardous Materials for First Responders Text.

Reading and understanding the text is required for completion of this class as well as certification.

Chapters 1 thru 3 are brief reviews of Awareness Level Responsibilities, the remainder are Operational Level Responsibilities.

Pay particular attention to items highlighted in **RED** throughout this program.

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What is a Hazardous Material?

Substances that possess harmful characteristics.

- In the United States they are called Hazardous Materials, or Haz-Mat.
- In Canada and some other countries they are called Dangerous Goods.

(Dangerous Goods used in both U.S and Canada for materials aboard aircraft)

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What is a Weapon of Mass Destruction (WMD)

When particularly dangerous hazardous materials are used as weapons and have the potential to cause mass casualties and damage.

CBRNE: Chemical, Biological, Radiological, Nuclear, or Explosive.

Hazardous Materials Incident

A ***"Hazardous Materials Incident"*** involves a substance that poses an unreasonable risk to people, the environment, and/or property.

Potential causes of a hazmat incident

- Human error, mechanical breakdowns/malfunctions.
- Container failures, transportation accidents.
- Deliberate acts; Chemical suicides, WMD incidents.

Haz Mat Incidents are Complex

- Present a variety of dangers.
- Be extremely difficult to control.
- Require specialized equipment, PPE, and procedures to ***MITIGATE.***
- Be difficult to detect without sophisticated monitoring equipment.

Roles and Responsibilities

- You must possess the skills necessary to address incidents.
- Understand the role you play.
- Understand your limitations, realize when you cannot proceed further.

Situational Awareness

Your roles are established by law and standards

- ***NFPA 1072***, Standard for Hazardous Materials/WMD Emergency Response Personnel Professional Qualifications.
- ***NFPA 472***, Standard for Competencies of Responders to Hazardous Materials/WMD incidents.
- ***NFPA 473***, Standard for Competencies for EMS Personnel Responding to Hazardous Materials/WMD Incidents.

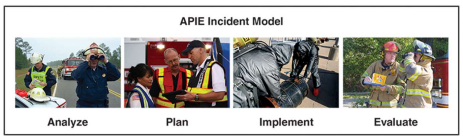
Three levels are addressed in this program

- **Awareness,** Lowest level of training, perform limited ***Defensive Actions*** (Call for help, evacuate the area, secure the scene).
- **Operations**, Dispatched to mitigate the incident performing ***Defensive Actions*** (Firefighters, Law Enforcement, Industry Personal, and others).
- **Operations-Mission Specific,** May be trained to perform additional ***Defensive Tasks and LIMITED Offensive Actions*** (Use specialized equipment and performs tasks where contact with the material may occur).

NFPA also identifies response personnel who perform more complex operations at hazmat incidents

- Hazardous Materials Technician.
- Hazardous Materials Technician With Specialty.
- Hazardous Materials Incident Commander.
- Hazardous Materials Officer.
- Hazardous Materials Safety Officer.
- Specialists.

The APIE Process can help responders devise a 4-step response to any Hazmat Incident



Awareness level personnel may be first at the scene and have the following responsibilities:

- Recognize a hazmat is present or potentially present at the incident, (Clues).
- Protect themselves and others from hazards.
- Communicate info to an appropriate authority and call for assistance.
- Establish scene control by isolating the hazard area and denying entry.

Situational Awareness

Awareness personnel are not responsible for planning the response but serve an important role.

Standard Operating Procedures (SOPs), Standard Operating Guidelines (SOGs) may help to determine initial actions.

Awareness personnel may be authorized to use the **Emergency Response Guidebook (ERG)** that will be learned in Chapter 3.

Initial actions can affect the course of the incident for better or worse.

Operational Level Responders

Respond to hazmat's as part of their duties and have the following responsibilities;

- ID the hazard.
- Identify response options.
- Implement the response to mitigate or control the release.
- Evaluate the progress.

Offensive tasks allowed by U.S. OSHA and Canada

Operational level responders with the ***appropriate training, PPE, and resources*** can perform offensive operations involving flammable liquid and gas fire control of the following;

- Gasoline.
- Diesel.
- Natural Gas.
- Liquefied Petroleum Gas (LPG).

Courtesy of Barry Lindley

Operational responders must analyze the incident

- Type of container involved.
- Hazardous Material Involved.
- Hazards presented by the material.
- Potential behavior of the material.

Photo by Pat Reynolds
Providence F.D. Special Hazards Unit

Analyze the surrounding conditions and determine the location and amount of release, if possible.

The Response

It **MAY NOT** be the responsibility of the Op's. Level responder to plan the response, but understanding tasks that need to be performed and why is.

It **IS THE RESPONSIBILITY** of the Op's. Level responder to establish the ***Incident Management System***, ***scene control***, and ***implement protective actions*** such as evacuation.

They must be able to;

- Follow safety rules.
- Use PPE correctly.
- Perform emergency Decon.
- ID and preserve potential evidence.

Evaluate the progress

Operational-Mission Specific Level

Operations personnel may be trained to perform mission-specific tasks with specialized competencies such as;

- Personal protective equipment.
- Mass decontamination.
- Technical decontamination.
- Evidence preservation & sampling.
- Product control.
- Air monitoring & sampling.
- Victim rescue & recovery.
- Response to illicit labs.

Hazardous Materials/WMD's can hurt you

- They may affect your health if they contact or enter your body and cause harm by their behavior and/or physical properties. (burn or explode).

Health effects may be Acute, Chronic, or Delayed

- **Acute:** Single exposure or several repeated exposures over a short period of time, appear in hours or days.

- **Chronic:** Long term, reoccurring that may take years to appear.
- **Delayed effects**, sometimes called ***latency period***, can take years to appear, such as cancer.

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Routes of entry (routes of exposure)

Many chemicals have multiple routes of entry.

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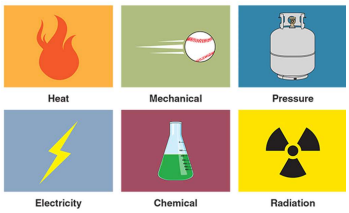
Mechanisms of Harm

Energy Release

There are 6 types



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TRACEM

Another way to categorize the types of harm

TRACEM	Mechanisms of Harm
➢ Thermal Hazards	Energy Released
➢ Radiological Hazards	Energy Released
➢ Asphyxiation Hazard	Toxicity
➢ Chemical Hazard	Corrosivity/Toxicity
➢ Etiological/Biological Hazards	Toxicity
➢ Mechanical Hazard	Energy Release

Corrosivity

Chemicals that destroy or burn living tissues.

More info will be provided in Chapter 2

Toxicity

Chemicals or biological substances that cause sickness, illness, or injury.

- ➢ Viruses
- ➢ Bacteria
- ➢ Toxins

Smallpox virus
Courtesy of CDC Public Health Image Library

More info will be provided in Chapter 2 & 4

Regulations, Definitions, and Statistics

Regulations have been enacted to address disasters

Courtesy of Moore Memorial Library, Texas City, TX

A ship carrying ammonium nitrate exploded at the dock.

Courtesy of Ray Elder

Six firefighters were killed after an unmarked trailer exploded.

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Regulations and Definitions

Four main U.S. federal agencies that are involved in the regulation of hazmat;

- Department of Transportation (DOT).
- Environmental Protection Agency (EPA).
- Department of Labor (DOL).
- Nuclear Regulatory Commission (NRC).

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Canadian Regulations and Definitions

- Transport Canada (TC).
- Environmental Canada.
- Health Canada.
- Canadian Nuclear Safety Commission (CNSC).

Mexican Regulations and Definitions

- Ministry of Communication and Transport (SCT).
- Ministry of Environmental and Natural Resources (SEMARNAT).
- Ministry of Social Welfare.

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Questions?

Hazardous Materials for First Responders

5th Edition

Chapter 10 - Implementing the Response: **Decontamination**

Introduction to Decontamination

Decontamination (Decon) is an essential activity that must be considered at any hazmat or terrorism incidents.

Emergency Decon should be established at all hazmat incidents and is performed to ensure the safety of responders.

Contaminates may be solids, liquids, or gases with varying hazards depending on the material involved *(chemical, physical, or biological)*.

Contamination is the transfer of a hazardous material to persons, equipment, and the environment.

There are two types of contamination, **direct contamination** and **cross contamination** (secondary contamination).

Decontamination (Decon) or contamination reduction is the process of removing hazardous materials to prevent the spread of contaminants;

- Beyond a specific area.
- To reduce contamination to levels that are no longer harmful.
- Prevents exposure by removing contaminants.

Exposure is the process where people, animals, or the environment are potentially subject to, or come in contact with, a material.

Decon operations minimize the potentially harmful exposures and reduce or eliminate the spread of contaminates.

Decon is performed to remove hazardous materials from;

- Responders.
- Victims.
- PPE.
- Tools.
- Equipment.

Courtesy of Boca Raton Fire Rescue

And anything else that has been contaminated as well as everyone and anything that has left the hot zone.

There are ***FOUR*** types of decontamination.

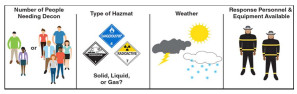
- Gross decontamination.
- Emergency decontamination.
- Technical decontamination.
- Mass decontamination.

Gross Decon

Decontamination also provides victims with psychological reassurance.

The effectiveness of any decontamination operation must be continually assessed. If monitoring determines the method is not working, try a different technique.

The types of Decon operations conducted at an incident will be determined by a variety of factors.



Decon operations at terrorist incidents may require some changes to hazmat/WMD procedures and may include large numbers of people that require a quick assessment of injuries or exposures.

Victims must be passed through Decon to a safe haven away from the incident.

REMEMBER; since a terrorist incident must be considered and treated as a crime scene, clothing, equipment, and/or contaminated materials have to be protected as evidence.

The basic principles of any Decon operation are;

➢ **GET IT OFF.** ➢ **CONTAIN IT.** ➢ **KEEP IT OFF.**

Before initiating any type of Decon procedure, answer the following questions;

- Do victims need to be deconned immediately or can they wait?
- Is it safe to conduct Decon and is there a safe place to do it?
- Is there alternative methods available?
- Are there adequate resources to conduct the operation?
- What is the time constraint required before victims deteriorate further?
- Is the equipment being deconned going to be reused or is it more cost effective to simply dispose of it?

Does decon save money or add value?

Decontamination Methods

Decon methods can be divided into **FOUR** broad categories:

Decon methods vary in their effectiveness for removing different substances and many factors play a part in the selection decision.

The most effective means of Decon may be as simple as removing the contaminated outer layer of clothing or PPE.

Flushing the contaminated surface with water is often effective at removing or sufficiently diluting material to a safe level.

Wet Decon

Wet Decon usually involve washing surfaces with solutions or flushing with water from a hose stream or safety shower.

Wet Decon methods may necessitate the collection of runoff water that may need to be analyzed for treatment and disposal.

Disposal of runoff water and residue from Decon operations must be accomplished in accordance with applicable laws and regulations.

Notify and consult the proper authorities.

Courtesy of the U.S. Marines, photo by Warren Peace

Life safety must take precedence over environmental considerations.

Dry Decon

Dry Decon may be as simple as removing contaminated clothing and placing into a suitable container, or allowing the contaminate to evaporate.

Other methods include;

- Vacuuming.
- Brushing.
- Scraping.
- Using sticky tape.

Caution: prevent the material becoming airborne.

Dry materials can also be used to remove liquid chemicals by absorption, but once used must be treated as contaminated waste.

Materials used for absorption may include:

- Clay.
- Sawdust.
- Flour.
- Dirt.
- Fullers earth.
- Tissue paper.
- Carbon.
- Silica gel.
- Paper towels.
- Sponges.

Courtesy of U.S. Army Staff Sgt. Fredrick P. Varney, 133rd Mobile Public Affairs Detachment

Physical and Chemical Decon

Physical methods remove the contaminant without changing the material chemically, which is then contained for disposal when practical.

Examples of physical Decon includes;

- Absorption.
- Adsorption.
- Brushing and scraping.
- Dilution.
- Evaporation.
- Isolation and disposal.
- Washing.
- Vacuuming.

Chemical methods are used to make the contamination less harmful by changing it through some kind of chemical process.

Examples of chemical Decon methods include:

- Chemical degradation.
- Sanitization.
- Disinfection.
- Sterilization.
- Neutralization.
- Solidification.

Used on equipment only, not on people.

Gross Decon

The phase of Decon where significant reduction of the amount of surface contaminant takes place as quickly as possible.

Traditionally accomplished by ***mechanical removal*** of the contaminant or ***initial rinsing*** from a handheld hose lines, emergency showers, or other nearby water sources.

Gross Decon may be accomplished by the following;

- Doffing PPE at the scene and using wipes or other Decon methods to remove soot from the face, head, and neck.
- PPE, tools, and equipment should be isolated, cleaned, and decontaminated according to SOP's.
- Machine wash structural firefighting PPE in designated machines back at the station is recommended.

Gross Decon has advantages and disadvantages and require follow-up.

An advantage; It is conducted in the field so the reduction of contaminants is immediate.

A disadvantage; Although it may remove the worst surface contamination, it *may not remove all*.

Gross Decon is not complete Decon and should be followed by more thorough decontamination.

Emergency Decon

The goal is to remove the threatening contamination as quickly as possible.

Emergency Decon may be necessary for both rescuers and victims by the removal of clothing (or PPE) and washing quickly.

Victims in need of immediate medical treatment cannot wait for a formal Decon corridor to be established.

The following are examples of instances where emergency Decon is needed;

* Failure of protective clothing or accidental contamination of responders.
* Immediate medical attention is required by emergency workers or victims in the hot zone.

Emergency Decon has both advantages and limitations

Limitations

- Removal of all contaminants may not occur.
- Emergency Decon can harm the environment.
- Environmental protection is important but should not delay lifesavings actions.
- Eradicating a life-threatening situation far outweighs negative effects.

Technical Decon

Responders must be familiar with the AHJ's procedures for implementing **Technical Decon** within the incident command system such as;

Positions

Roles

Responsibilities

Operational Level Responders will typically act as follows;

- Protect themselves by wearing PPE.
- Establish a water supply.
- Set up a Decon corridor.
- Establish perimeters.
- Perform physical Decon activities, (scrubbing, washing, and spraying).
- Assist with undressing/removal of PPE or clothing of others going through Decon.
- Assist the individuals through the process.
- Perform other duties per SOP/G's and training.

Resources for determining **Technical Decon** procedures may include the following;


Tech. Class 305-11

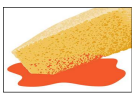
- First Aid section of SDS sheets.
- Emergency response centers.
- Container info labels.
- Pre incident plans.
- Technical experts.
- *ERG*.
- Poison control centers.
- Other books, reference sources, computer programs, and data bases.

NOTE: Monitoring should be conducted to determine the effectiveness of ***all*** types of Decon.

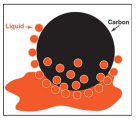
Technical Decon Techniques

Various techniques may be used and responders must know what to do when assigned to a Decon corridor, (briefings should be held).

Absorption: The process of picking up hazardous liquids with absorbents.



Adsorption: The process in which a hazardous liquid interacts with or is bound to the surface of a sorbent material.



Brushing and Scraping: May remove large particles of contamination but alone is not sufficient Decon.

Chemical Degradation: Uses a material (ex. bleach), to change the chemical structure of a hazardous material.

Dilution: The process of using water to flush contaminants from victims or objects and diluting water-soluble hazmat's to safe levels.

Evaporation: The process of liquid turning into a gas.

Tech. Class 305-11

Isolation and Disposal: Contaminated items are isolated by collecting them and then disposing in accordance with applicable regulations and laws.

Neutralization: Changes the pH of a corrosive by raising or lowering it towards 7 (neutral).

Sanitization: Reduces the number of microorganisms to a safe level.

Disinfection: Kills most of the microorganisms with the use of a variety of chemical or antiseptic products.

Sterilization: kills all microorganisms with chemicals, steam, heat, or radiation but is usually impossible or impactable to do in most Decon onsite situations.

Solidification: A process that takes a hazardous liquid and treats it chemically so that it turns into a solid.

Vacuuming: Using high efficiency particulate air (HEPA) filter vacuum cleaners to pull solid materials from surfaces.

Washing: Similar to dilution in that they are both wet methods, however washing involves using prepared solutions such as soap and or detergents mixed with water.

Technical Decon for Ambulatory Victims

Ambulatory victims are able to understand directions, talk, and walk unassisted.

Technical Decon corridors;

- Are typically designed for ambulatory persons.
- May be set up for wet or dry Decon methods.
- Varies in the number of stations depending on the situation.

May be as simple as washing hands and face with soap and water.

Technical Decon for Nonambulatory Victims

- Civilians or responders who are unconscious, unresponsive, or unable to move unassisted.
- May be more seriously injured.
- Need assistance being removed to Decon area.
- May have to remain in place if sufficient personal are not available to remove them from the hot zone.

Mass Decontamination

Operational Level responders involved in mass Decon operations must work under guidance from resources such as;

* Hazmat Technicians.
* SOP/SOG's.
* Allied professionals.

A mass Decon incident may be quite chaotic and difficult to control, particularly if it is a **mass casualty incident**.

Remember, victims may be traumatized or suffering from exposure, so to combat the chaos of the incident, responders should take the following actions;

- Communicate with the victims directing them to Decon area as well as through the process.
- Provide simple and specific directions that are easily understood and mark the Decon corridors.

Know the Decon method to be used; **Dilution – Isolation – Washing.**

As discussed earlier, each of these methods have their own advantages and limitations.

Washing with soap and water solutions or universal Decon solutions will;

* Remove any hazardous materials and WMD agents.
* The solutions may not be available in sufficient quantities.

Mass Decon can be most readily accomplished with simple water shower systems as it dilutes the hazardous product and physically washes it away.

Mass Decon uses ***large volumes*** of water at ***low pressures*** in a fog pattern.

Mass Decon showers should ensure that the process physically removes the hazardous materials.

- The actual showering time is an incident specific decision.
- Showering time may be shortened if large numbers of victims are involved.
- Time may also depend on water availability.
- Post Decon evaluation should validate Decon effectiveness.

Never delay Decon while waiting for additional resources unless an assessment has been made that further injury or exposure will not occur.

Do not overlook existing facilities when identifying means for rapid Decon methods.

- Activation of overhead fire sprinklers.
- Public fountains, swimming pools, locker rooms, as well as other water recreation areas.

Consideration must be given to the persistence of the chemical agents in contained and contaminated water.

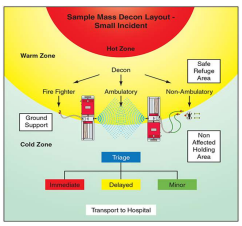
Removal of as much clothing as possible and showering can remove significant amounts of the contamination.

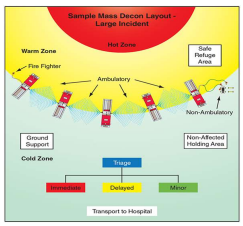
Contaminated clothing must be isolated and an accountability system for personal belongings and valuables put in place (Victim privacy issues).

Many innovations and products have been developed to assist in mass Decon operations.

- Decon trailers and portable tents.
- Bagging and tagging systems.
- Portable water heaters.
- Disposable coveralls.

Apparatus placement may be different for small and large incidents.





More than one Decon corridor may be required depending on victim priorities.

- Consider factors related to medical needs and Decon.
- Separate Decon corridors may be required.
- Provide separate Decon line for response personnel.
- If possible separate by gender for privacy reasons.
- Keep families together.

Non ambulatory victims may not be able to walk through the Decon corridor.

Mass Decon for Ambulatory Victims

Direct ambulatory victims to safe area for prioritization.

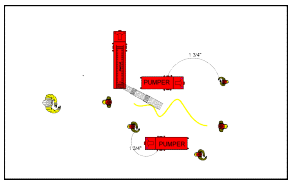
The following factors may influence the priority treatment for ambulatory victims;

- Victims with serious medical symptoms (shortness of breath, chest tightness).
- Victims closest to the point of release.
- Victims reporting exposure to the hazardous material.
- Victims with evidence of contamination on clothing or skin.
- Victims with injuries such as broken bones or open wounds.

Ambulatory decon layouts direct victims through decon to triage and may provide modesty clothing.

Apparatus can be effectively placed for emergency or mass decon.

RAM Decon Setup



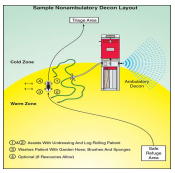
Mass Decon for Nonambulatory Victims

Nonambulatory victims may be more seriously injured than ambulatory victims.

Nonambulatory victims may have to remain in place if sufficient personnel are not available to remove them from the hot zone.

The decon process for nonambulatory victims at mass casualty incidents will be more of a gross decon process conducted quickly.

Apparatus can be used in both nonambulatory and ambulatory corridors.



Victim management during decon operations

Victim management activities during decon includes ***Triage*** and ***Handling deceased victims***.

Triage may be necessary for victims involved in hazmat incidents and is conducted in the cold zone.

All victims **MUST** undergo decon **BEFORE** being transferred to EMS.

Deciding to use technical or mass decon depends on the following;

* Type of exposure.
* Injuries present.
* Products involved.
* Other factors.

The START or other type of triage system can help with victim management.

START Medical Triage System

START Category	Decon Priority	Classic Observations	Chemical Agent Observations
IMMEDIATE Red Tag	1	Respiration is present only after repositioning the airway. Applies to victims with respiratory rate >30. Capillary refill delayed more than 2 seconds. Significantly altered level of consciousness.	• Serious signs/symptoms • Known liquid agent contamination
DELAYED Yellow Tag	2	Victim displaying injuries that can be controlled/treated for a limited time in the field.	• Moderate to minimal signs/symptoms • Known or suspected liquid agent contamination • Known aerosol contamination • Close to point of release
MINOR Green Tag	3	Ambulatory, with or without minor traumatic injuries that do not require immediate or significant treatment.	• Minimal signs/symptoms • No known or suspected exposure to liquid, aerosol, or vapor
DECEASED/ EXPECTANT Black Tag	4	No spontaneous effective respiration present after an attempt to reposition the airway.	• Very serious signs/symptoms • Grossly contaminated with liquid nerve agent • Unresponsive to autoinjections

Courtesy of the U.S. Army Soldier and Biological Chemical Command (SBCCOM)

Page 505.

Deceased victims must undergo decon before transport to the medical examiner.

- Be mindful of the need to preserve the incident scene.
- Specialty response teams may be requested to assist if there are large numbers of deceased victims.
- In the U.S. and Canada, these teams must be requested through the appropriate emergency management office.
- An on scene morgue facility may have to be established.

General Guidelines for Decon Operations

- Assess all victims believed to have been in the hot zone to determine the need for decon prior to moving to the cold zone.
- Establish clearly designated Decon entry points. Remember, both victims as well as responders must go through Decon.
- The more clothing removed the better (complete disrobing is usually not needed).
- Decon all emergency responders separately from victims.
- Establish medical triage and treatment area just outside Decon zone (cold zone).

Provide warm water for washing if possible. If water is cold, allow victims to get wet gradually in order to acclimate to the temperature, avoiding cold shock.

Document and preserve (safeguard the condition of), belongings of victims deconned for future identification of victims and forensic examination.

Provide victims and responders with clean alternative clothing to maintain their privacy and protect them from the weather.

Use NIOSH guidelines to determine the appropriate protective clothing for technical decon.

Often, those conducting decon are dressed in as ensemble classified one level below that of the entry team.

Courtesy of FEMA News Photos, photo by Win Henderson

Wear chemical gloves, not leather fire-fighting gloves during decon procedures.

Decon Implementation

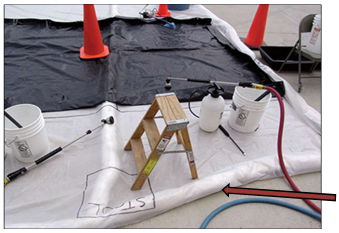
The following factors will be discussed when implementing Decon;

- Site selection.
- Decon corridor layout.
- Decon security considerations.
- Cold weather Decon.
- Evidence collection & Decon.
- Evaluating the effectiveness of the Decon.

Decon Site Selection

Consider the following factors when selecting a Decon site;

- Wind direction and weather.
- Accessibility and Time requirements.
- Terrain and surface materials.
- Lighting and electrical requirements.
- Drains/waterways and water supply.



Using flooring made up of tarps, plastic sheeting, or salvage covers when the Decon corridor is on a hard surface.

Notice the protective diking.

Decon Corridor Layout

Establish the Decon corridor *before* any hot zone work begins.

First responders are often involved with setting up and working the Decon corridor which can be straightforward requiring few steps, or complex requiring many steps.

Emergency responders must understand the process and be trained to set up the type of Decon required by different materials.

Decon corridors should be designed to keep families an caregiver's together as well as ensuring victim privacy and security.

Bag and tag contaminated clothing and personal effects.

- Place clothing and/or personal effects in a labeled bag.
- Separate personal effects into clear plastic bags (clothing/jewelry etc.).
- Clearly mark the bags with name or unique number system for return to owner after the incident, commercial tagging systems may be used for this purpose.
- Items may need to be Deconned before being returned.
- Bags containing contaminated clothing should remain on the dirty side of the decon line.

Identify the Decon corridor with visually recognizable items.

- Barrier tape safety cones, etc.
- Salvage covers or plastic sheeting can be used.
- Containment basins/pools can be used.

Decon Safety Considerations

Law enforcement and military personnel leaving the hot zone must undergo Decon.

Courtesy of the U.S. Air Force, photo by Staff Sgt. C. Todd Lopez.

Policies must be established for the Decon of weapons, ammunition, and other equipment.

Service dogs leaving the hot zone must be Deconned as well.

Usually service animals are required to stay with their handlers and fire personnel may have to assist in the Decon of animals.

Criminal suspects will go through the same decon steps established for responders and other victims.

Consideration must be given to whether or not handcuffs must be removed and decontaminated.

Follow department procedures for the Decon of criminal suspects, animals, pets, and support animals.

Cold Weather Decon

Answer the following questions on how to best protect the victims;

- Are wet methods necessary or can disrobing and dry methods be effective?
- Is wind chill a factor and is shelter available during and after Decon?
- Is it possible to conduct Decon indoors, if so will the victims need to be transported there, if so how?
- If Decon is conducted outside, how will icy conditions be handled?

Evidence Collection and Decon

Know the procedures for the Decon of evidence.

Evidence collected by law enforcement must be;

- Appropriately packaged in approved bags or other containers.
- Only the exterior packaging will undergo Decon.
- Must document chain of custody.

Evaluating the Effectiveness of Decon Operations

- Evaluating the effectiveness of Decon may be done visually or with monitoring devices or other equipment.
- Check each person after Decon has been completed for victims that are still complaining of symptoms or effects.
- If the effectiveness of Decon is called into question, victims should go through Decon again.
- Tools and equipment will be stored in the Decon area until the emergency phase is over, then Deconned or isolated for disposal.

Courtesy of New South Wales Fire Brigades.

Always verify the effectiveness of Decon operations.

Termination of Decon Activities

Multiple steps are involved in the termination of Decon activities.

- Debrief those involved in the incident as soon as practical.
- Provide exposed victims with as much info as possible about delayed health effects of the materials involved.
- Return personal items to persons undergoing decon unless there are evidentiary issues.

Additional reports and supporting technical documentation will have to be completed such as;

* Incident reports.
* Regulatory citations.
* After action reports.
* Exposure records.

Exposure records ***are required*** for all first responders who have been exposed or potentially exposed to hazardous materials.

Information recorded on the exposure report can include;

- Activities performed and materials involved.
- Reason for being there and any equipment failures.
- Malfunction of PPE and hazards associated with the product.
- Symptoms experienced and monitoring levels in use.
- Circumstances of exposure.

Questions?

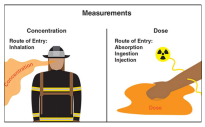
Hazardous Materials for First Responders

5th Edition

Chapter 11 - Implementing the Response: **Mission-Specific Detection, Monitoring, and Sampling**

Concentration, Dose, and Exposure Limits

Responders use detection and monitoring equipment to detect, and measure the concentration or doses of hazardous materials.



Devices that measure ***concentration*** generally indicate measures of the material responders might inhale.

Devices that measure ***dosage*** generally indicate measures of materials that may enter responders bodies via means other than inhalation.

Determinations may be made by responders by referencing the **exposure limits** of the materials.

Exposure limits refer to values expressing the maximum dose or **concentration** to which individuals should be exposed given a specific time frame.

Sources will often state concentrations of a substance in many different terms.

- **Parts per million (ppm)**. May describe the concentration of a gas or vapor in air or the concentration of a specific material in a liquid or solid.
- **Parts per billion (ppb)**. May describe the concentration of a gas or vapor in air or the concentration of a specific material in a liquid or solid.

See pages 531-532 for a complete list of terms.

The **NIOSH** *Pocket Guide to Hazardous Materials* and other resources provide exposure limits and other important terms such as;

- **Permissible exposure limit (PEL)**: Concentration (measured in ppm or mg/m³) in which most people are not adversely affected (40-hour week/8-hour day).
- **Immediately dangerous to life or health (IDLH)**: Concentrations high enough to kill or cause serious injury or illness.
  Table 11.1 on pages 534-536 lists terms given by various agencies.
- Rather than concentrations, some meters provide the ***percent*** of oxygen in air or ***percentage*** of the lower flammable(explosive) limit(LFL).

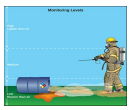
Detection, Monitoring, and Sampling Basics

Detection, monitoring, and sampling assist in the following mitigation tasks;

- Identify the hazards.
- Determine appropriate PPE, tools and equipment.
- Determine perimeters and scope of the incident.
- Check and ensure the effectiveness of Decon operations.
- Detect leaks from containers or piping systems.
- Monitor the contamination level of Decon runoff.

You must know how to detect and interpret concentration levels of materials by coupling what you know about the behavior of the material as well as understanding the detection devices you will use.

The state of matter of the sampling material will affect the monitoring and detection techniques and the devices used.



Because vapor densities vary and air currents can move gases and vapors in unexpected ways, samples must be taken at different heights.

Remember: most gases sink and displace air, while only a few rise and float.

The user must practice with and work together with the instrument.

Responders using detection, monitoring, and sampling devices must;

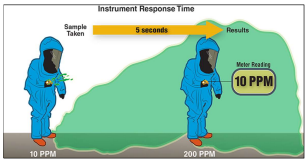
- Understand the capability of each device and use it correctly.
- Understand what is being measured and how instruments relay info.
- Accurately interpret the data provided by each device.
- Maintain, field test, and calibrate devices per manufactures instruction.

Use predetermined procedures based on availability, capabilities, and limitations of personnel, PPE, and other resources available.

Verify monitoring and sampling results when possible by using more than one sampling method and more than one technology.

Safety is jeopardized when devices are not used correctly and their limitations are not understood.

Instrument response time may take several seconds, so if responders move too quickly they may find themselves in a concentration of the material that is much higher than the meter indicates.



Personnel conducting samples must follow procedures to preserve evidence and maintain chain of custody.

For any recordings to be admissible a evidence, protocols must be followed in regards to;

- Chain of custody.
- Packaging and labeling.
- Transport of evidence to the testing authority.

Regardless of the mission, hazmat incidents will always require size-up and risk assessment.

When materials are unknown, take an analytic approach.

Attempt to identify and characterize the hazards present by monitoring for the following;

- Corrosives.
- Exothermic reactions.
- Flammables.
- Oxidizers (and explosives).
- Oxygen levels.
- Radiation.
- Toxics.

Have a plan and address these questions before you begin a monitoring activities.

- What purpose does the monitor serve?
- What readings should you anticipate?
- Which instrument will detect the materials under the current conditions?
- Is there more than one hazard present?
- How will current conditions such as rain, humidity, or temp. affect the devices?

To stay safe while monitoring, follow these steps;

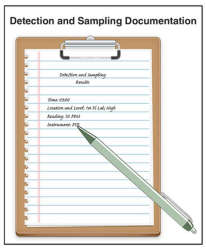
- Operate under the direction of a hazmat tech., specialist, or allied professional.
- Follow written procedures and understand the limitations of the devices. (Follow manufactures instructions for **calibration** and use).
- Remove damage devices from service immediately.
- Be consistent – always wear your appropriate PPE.
- Work with a buddy (backup team ready) and approach the hazard from upwind.
- Follow local protocols and SOP/G's (alarm or detection) among others.

Always assume more than one hazard is present.

Document your results.

* Time of the reading.
* Location and level of the reading.
* Readings obtained.
* Instrument used.

Always follow AHJ protocols for reporting readings to the Incident Commander.

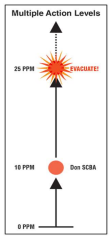


Action Levels

The response to known or unknown chemicals that will trigger some action.

When an action level (or action point) is reached, it may trigger;

- Removal of unprotected/unnecessary personnel.
- Additional monitoring.
- Alteration or adjustment of PPE.
- Total area evacuation.



Determining PPE

Determine which protective resources and features will be necessary during detection and monitoring operations, (remember the factors discussed in chapter 9).

Maintain **SITUATIONAL AWARENESS** and adhere to the instructions of the I.C. and the AHJ at all times.

Remember; solids, liquids, and gases behave differently, therefore operate with extreme caution at incidents involving gas releases.

Ton cylinders, compressed gas cylinders, and high pressure vessels are likely to release gases and may require vapor-protective clothing.

Selection and Maintenance of Detection, Monitoring, and Sampling Devices

Consider the following when determining what equipment to use;

- Sensitivity and selectivity.
- Calibration. (**Calibration test** and **zeroing**).
- Training.
- Instrument reaction time.
- Mission of the operation.
- Suspected hazards involved.
- Portability & user friendly.

When purchasing detection and air monitoring equipment, consider;

- Contact current users to get info about the equipment.
- Include cost of probes, filters, internal parts, and calibration.
- Reduced reliability, reaction time during each use, and the affect of moisture, temperature, and atmosphere on the operation of the device.

Remember, **know and use the correct manufacturers recommended** calibration gases and;

- Store the devices in accordance with manufacturers recommendations.
- Be aware of expiration dates/shelf-life of sensors, test strips, and tubes.
- Test the instrument's routinely to ensure proper operation.

Hazard Detection Equipment

Responders should follow the SOP/G's of the AHJ for identifying hazards in the field.

Different hazards are detected and monitored for by different devices;

- Corrosives.
- Flammables.
- Oxidizers.
- Oxygen.
- Radiation.
- Reactives.
- Toxics.

A large percentage of hazmat incidents involve corrosives that can damage equipment.

The primary equipment for detecting and measuring corrosivity is pH paper and pH meters, which provide more precise readings than pH paper.

pH is the concentration of **hydronium** or **hydroxide** ions in a solution that determines the solutions pH.

Concentration is the ratio of the amount of a chemical to the amount of water.

Strength of an acid or base is determined by the number of hydrogen ions produced.

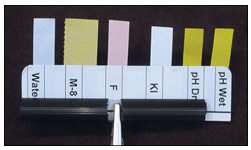
pH paper changes color when it comes in contact with corrosive materials.

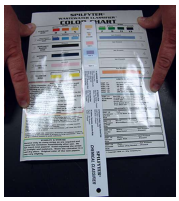
Acid

Base

Fluoride test paper detects compounds containing fluorine, the most reactive of all chemical elements.

Testing paper can be purchased unassembled or preassembled.





Flammables are measured by devices called **combustible gas indicators (CGI's)** that measure in percentage of the LEL, PPM, or percent of gas per volume of air.

CGI's have specific calibration issues and is calibrated to a specific flammable gas (methane, pentane, propane, or hexane).

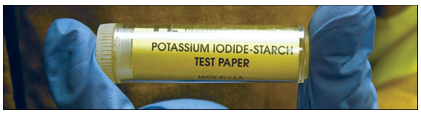
CGI's need specific oxygen levels to operate properly and can be influenced by the following;

- Chlorinated hydrocarbons.
- Oxygen-acetylene mixtures.
- Catalyst poisons.
- Concentrations exceeding 100% of the LEL.
- Concentrations exceeding the UEL.

Some released materials act as **Oxidizers** and can be detected with test strips.

Organic peroxides can initiate explosive polymerization in certain materials, are components of improvised explosives, and can be detected by peroxide test strips which will turn blue after contact for 15 seconds.

Potassium iodide (KI) starch paper can be used to test the oxidizing potential of unknown chemicals.

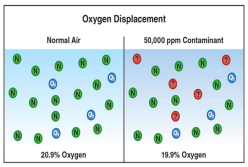


Oxygen meters detect the percentage of oxygen in the air, monitor oxygen levels even when wearing your SCBA.

Many devices cannot function properly without sufficient oxygen.

Normal air contains 20.9% oxygen.
A reading below 20.9% indicates a contaminant is displacing the oxygen.

A 1% drop in oxygen is equal to 50,000 ppm of something else in the air.



- **Sievert (Sv):** SI Measurement of low level radiation of does equivalent.
- **Gray (Gy):** SI Measurement of absorbed dose of ionized radiation.

The common conversion factor among exposure, absorbed dose, and dose equivalent for gamma and x-ray radiation is: 1 R =1 rad =1 rem

See table 11.4 on page 558 for unit equivalents.

Handheld portable survey instruments are the simplest and most affordable option to detect radiation and contamination.

There are three groups of radiological instruments;

1. For measuring radiation exposure.
2. For detection of radiation contamination.
3. For dose monitoring and personal dosimetry.

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The two general categories of detectors are gas-filled detectors and scintillation detectors.

- **Gas-filled detectors:** Radiation ionizes the gas in the detection chamber and the electronics measure the quantity of the ions created.

  Common types of gas-filled detectors include ion chambers and **Geiger-Mueller (GM) tubes,** first known as **Geiger Mueller (GM) detector.**

- **Scintillation Detectors:** Radiation interacts with a crystal to produce a small flash of light that is amplified thousands of times by the device using a photomultiplier tube to produce a useful signal.

These devices are susceptible to breakage if not handled properly.

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Monitoring and Dosimetry devices help wearers keep track or their total accumulated radiation dose.

There are several different types of **dosimeters** available. Some commonly used "self-reading" personal dosimeters do not require processing at a lab to retrieve dose information.

A self-reading **dosimeter** (SRD) measures the radiation dose in Roentgens (R), milliroentgens (mR), sieverts (Sv), or gray (Gy).

SRD's only measure gamma and x-ray radiation and have been called; Direct reading dosimeters (DRD), Pocket ion chamber (PIC), or pencil dosimeters.

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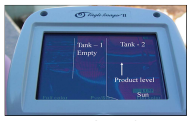
Reactives; Released materials can react with themselves or each other.

While there is no meter or device that can detect reactive materials, potentially hazardous chemical reactions will cause a temperature change.

To check for this type of reaction, aim an **infrared thermometer** (or temperature gun) directly at the container.

In addition to temperature, thermal imagers may also be used to detect liquid levels at hazmat incidents.



Courtesy of Barry Lindley.

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Toxics: Many different technologies detect toxic materials.

Toxic compounds produce an effect primarily as a function of ***dose*** (amount of the substance ingested or absorbed through skin contact) or ***concentration*** (the amount inhaled) of the compound.

The term **dose-response relationship** is a key concept in toxicology. (As the dose increases, the severity of the toxic response increases).

Example: People exposed to 100 ppm of tetrachloroethylene, a **solvent** commonly used for dry cleaning may experience mild symptoms such as headache or drowsiness. Those exposed to 200 ppm may lose motor control and those exposed to 1500 ppm for 30 minutes may lose consciousness.

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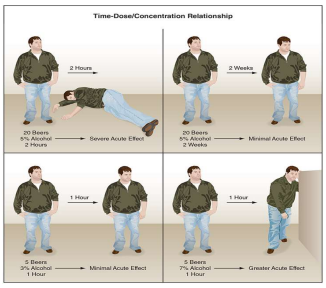

A dose spread over a long period of time may have less effect than the same dose administered over a shorter time period.

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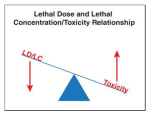
Poisons and the measurements of their toxicity are often expressed, on safety data sheets, in terms of **lethal dose (LD)** for amounts ingested and **lethal concentration (LC)** for amounts inhaled.

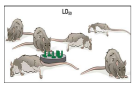
Lethal dose indicates the minimum amount of solid or liquid that when ingested, absorbed, or injected through the skin will cause death.



Sometimes the lethal dose is expressed in conjunction with a percentage such as LD_{50} (most common) or LD_{100}.

The number refers to the percentage of an animal test group that the listed dose killed.

Median lethal dose (LD_{50}) causes death in 50 percent of animals when administered orally.



Lethal dose low (LDLO or LDL): the lowest administered dose of a material capable of killing a specific species.

Lethal concentration (LC) indicates the minimum concentration of an inhaled substance in gaseous state that will kill the test group (usually within 1 to 4 hours).

Similar to LD, sources may express median lethal concentration as **LC_{50}.**

Lethal concentration low (LCLO or LCL) indicates the lowest concentration of a gas or vapor capable of killing a specific species over a specified time.

Incapacitating dose (ID) for on organism (such as a human being) indicates the dosage of a chemical or substance required to incapacitate that organism.

It is expressed similarly to lethal dose and lethal concentration and can vary from moderate (unable to see, breathless) to severe (convulsions).

Chemical warfare agents commonly lists Incapacitating Dose (ID).

Categories of incapacitating dose include;

ID_{50} - Dose that incapacitates 50 percent of the population of interest.

ID_{10} - Dose that incapacitates 10 percent of the population of interest.

Chemical Specific Detectors

Some chemical monitors use sensors designed to detect a single chemical, such as;

Carbon monoxide - Hydrogen sulfide - Ammonia – Chlorine - Hydrazine - Ethylene oxide - Hydrogen cyanide - and Phosgene.

Some monitors may combine these sensors with a CGI and O2 sensor to form two-, three-, or four-gas monitors.

A typical four gas monitor will detect LEL, oxygen, carbon monoxide, and hydrogen sulfide.

Photoionization Detectors (PIDs):

- Uses an ultraviolet lamp to ionize samples of gaseous materials.
- Can detect very low concentrations of many organic and some inorganic gases and vapors.
- They make a good general survey instrument, capable of detecting and measuring concentrations in real time.
- They can determine the presence of a contaminant but cannot identify the material.
- Most PID's use several different lamps (bulbs) to measure the **ionization potential (IP)** of a material. (10.6 bulb is used for emergency response)

As with all meters, PID's have limitations such as;

- Some are not intrinsically safe so a CGI must be used as well.
- PID cannot identify unidentified/unclassified substances.
- Detection of ionization may take several steps and some materials may require the use of **correction factors**.
- PID's don't respond to an IP greater than the lamp and require filtration in high humidity and rain.
- The lamp window must be cleaned periodically and all other manufacture requirements must be followed.

Colorimetric Indicator Tube consists of a glass tube filled with an indicating chemical.

- The tube is connected to a piston or bellows type pump.
- A known volume of contaminated air at a predetermined rate is pulled through the tube.
- The contaminant reacts with the indicator chemical, producing a color change where the length marks are proportional to the concentrations.

Colorimetric Tubes are generally chemical specific.

Some manufacturers do produce tubes for groups of gases, such as aromatic hydrocarbons or alcohols.

A filter may precede the indicating chemical to;

- Remove contaminants and humidity that interfere with the measurement.
- React with a contaminant to change it into a compound that reacts with the indicating chemical.

Questions?

Hazardous Materials for First Responders

5th Edition

Chapter 12 - Implementing the Response: **Mission-Specific Victim Rescue and Recovery**

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Operational level responders may have to perform rescue operations at hazmat incidents, therefore must be trained and equipped to do so.

Various tasks and safety procedures must be met at Hazmat/WMD rescue operations which depend on the following;

- Incident type.
- Number of living victims.
- Location of the victims.
- Whether the victims are ambulatory or not.

Risk/Benefit

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Successful rescue and recovery operations are developed and implemented carefully.

To succeed, these operations require the following;

Courtesy of U.S. Marine Corps, photo by Sgt. Christopher D. Reed.

- Training.
- Comprehensive understanding of the rescue process.
- Info about local capabilities and facilities.
- Skills necessary to perform rescues safely and efficiently.
- Have a rescue plan.

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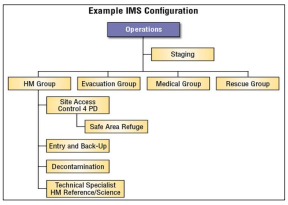
Responders must work within the ICS structure, follow established procedures, local emergency response plan, and under the supervision of a Hazmat Technician, Allied Professional, or SOP.



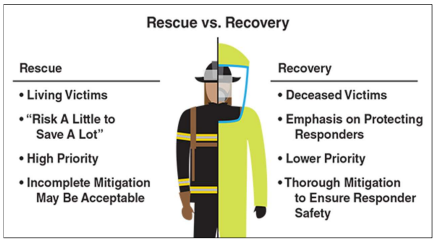
Appropriate training will help responders maintain control at mass casualty incidents.

The feasibility of conducting a rescue in a contaminated environment must be considered.

Answering the following questions may help;

- Can the hazard (and products) be identified?
- What are the other known factors about the incident?
- Have witnesses provided additional info useful to the decision making process?
- Are victims within line of sight or is a search needed?
- Is it a rescue operation or a recovery operation?

Be aware that rescue and recovery operations have different priorities.



Determine if sufficient resources are available for the mission.

- Do responders have the PPE and training necessary for the mission?
- Do responders have the necessary equipment needed?
- Are there enough personal available to safely conduct a rescue?
- Is there instruments available that can identify possible hazards?
- Are other resources available that could be helpful such as the ERG, NIOSH Pocket Guide, or SDS's?

Planning for a rescue takes into account all hazards and limitations affecting the responder an the scene.

- Hostile human threats.
- Number and training level of available responders.
- Incident circumstances.
- PPE available.

Courtesy of the U.S. Marine Corps

Unit leaders, supervisors, Technician Level Responders, and Allied Professionals have roles during operation planning.

The ***unit leader*** has many responsibilities before executing the operations.

Unit leaders and supervisors are responsible for overseeing safety of entry teams.

The ***unit leader*** does not don CPC unless the situation indicates that a suit is required to properly supervise the operation.

Hazmat Technicians and Allied Professionals are responsible for risk assessment and the selection of control options.

Decontamination stations should be established before entry.

The entry team must consist of at least two trained members in appropriate PPE who will perform the actual search, rescue, and removal of victims from the hazard zone.

Team members must work in the "buddy system" and maintain radio contact.

If one member must leave, the other member must leave as well.

If one of the entry members is injured, the other member must notify the backup team that an immediate rescue is needed.

The backup team stays on standby to perform a single task:
<u>the removal of a downed responder.</u>

Consists of two trained members in appropriate level of PPE.

The operating time of this group should be less than the entry teams.

The unit leader must provide functional supervision at all times.

Hazmat rescues start at the incident's ***outer edges and work inward.***

Rescue priorities are to reach less affected/ambulatory victims first.

Direct your efforts at visible victims and then focus on victims out of sight.

Always address ambulatory victims within the **line-of-sight** first.

Controlling contaminated victims minimizes responder's risk of exposure and aids in the ensuing investigation.

Avoiding touching contaminated victims will allow an interview by law enforcement to be conducted sooner if the incident is a crime scene.

After **line-of-sight** ambulatory victims, nonambulatory victims within the **line-of-sight** can be focused on next.

This type of rescue is dependent on tools and equipment.

Follow local SOP's to determine which nonambulatory victims should be moved to the decon area.

Nonambulatory victims not within the line-of-sight are the last to be rescued from the hot zone.

These victims are generally the closest to the hazardous materials/WMD event and have experienced the greatest exposure and related dose.

Rescue and removal of these victims poses the greatest danger to emergency response personnel.

Triage is conducted after victims have been removed from the hot zone where priority for decon is determined.

A more thorough triage will be conducted after victims have gone through decon.

One common system requires responders to quickly assess a victims status and assign them into four basic categories;

Priority 1	Priority 2	Priority 3	Priority 4
Life-threatening injuries and illnesses (highest priority).	Serious, but not life-threatening injuries.	Minor injuries.	Dead or fatally injured.

Rescue and recovery operations requires specialized tools and equipment including;

- PPE and equipment suitable for the hazards present.
- Triage tags.
- Backboards and **Stokes Baskets** to quickly package victims.
- **SKEDs®**, carts, buggies and other equipment to move victims.
- Extrication equipment.
- Technology used to search for victims.

Cart

SKED®

Courtesy of the U.S. Marine Corps.

Responders must be trained in the use of such equipment, and the equipment must be maintained in good condition.

Rescue Methods

An uninjured victim or one with minor injuries may be directed using hand signals or verbal instructions to walk to safety .

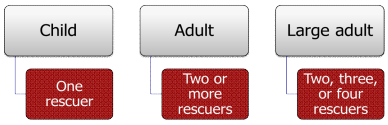
If physical assistance is needed, one or two rescuers may be required depending on how much help is available and the size and condition of the victim.

Caution must be exercised when moving an injured victim from the hot zone so not to aggravate a spinal injury.

In an extreme emergency, possible spinal injury becomes secondary to preserving life. Pull victim in the direction of long axis of the body.

The number of rescuers needed to transport a victim can vary.

There are a number of lifts, carries, and drags that may be used to move victims quickly.



Realistically, in very hostile environments, victims are removed by whatever means are available at the moment, such as grabbing an arm, leg, clothes, belt, hair, or whatever works.

Recovery Operations

All viable victims should be rescued before **recovery** operations begin.

Rescue is the removal of both ambulatory and nonambulatory victims who are still living and who have a likelihood of surviving their injuries or exposure.

Recovery operations are a lower priority and should be coordinated by the IC with law enforcement or coroner personnel.

It may be necessary for bodies and human remains to remain in place until law enforcement or investigative efforts are complete.

Questions?

Hazardous Materials for First Responders

5th Edition

Chapter 13 - Implementing the response:
Mission-Specific Product Control

Spill control tactics confine a hazardous materials that has been released from its container.

It is an attempt to;

- Reduce the amount of contact (contamination) made with people, property, and the environment.
- Limit the amount of potential harm caused by the product.

Control actions involving spills are generally ***defensive*** in nature.

Spill control is used to prevent further contamination and is often called **confinement**.

Some control tactics such as **neutralization** and dispersion minimizes the harm that the material causes.

Responder safety is always a primary consideration.

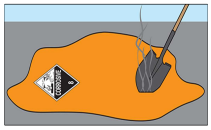
Spills may involve gases, liquids, or solids that may be released into the air, (as a vapor or gas), into water, and/or onto the surface.

Methods used to prevent the spread of liquid materials include building dams or dikes, catching the material in another container, or directing (diverting) the flow to a remote location.

Before any confinement operations begin, the IC must seek technical advise to determine if the material will affect the equipment used.

Corrosive materials may react with metals and damage equipment.

Other specialized equipment may be required.



Spill control is not restricted to controlling liquids, responders may need to control dusts, vapors, and gases with the following;

- Protective covering of a fine spray of water.
- A layer of earth.
- Plastic sheets, salvage covers, or foam blanket.

The following dictate confinement efforts;

- Material type.
- Size of release.
- Speed of release.
- Number of responders available.
- Tools and equipment needed.
- Weather and topography.

Don't contact the material

Operations level responders take protective actions.

Do not stop a leak unless a remote shut off device is used.

Defensive spill control tactics include;

- Absorption.
- Adsorption.
- Blanketing/covering.
- Dam, dike, diversion, and retention.
- Vapor suppression.

Other tactics involving changing the materials physical/chemical properties are;

- Vapor dispersion.
- Ventilation.
- Dispersion.
- Dilution.
- Dissolution.
- Neutralization.

Table 13.1 on page 610 provides spill control tactics by type of release.

Absorption

Like a sponge soaking up water.

The absorbent used must be compatible with the material being absorbed.

Absorbents tend to swell as they absorb a material.

Common absorbents are ;

- Sawdust.
- Clays.
- Charcoal.
- Polyolefin type materials.
- Specialized designed pads, booms, pillows, and socks.

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Adsorption

The molecules of the liquid physically adhere to the adsorbent material rather than being absorbed into its inner spaces.

Adsorbents tend not to swell like absorbents do.

Organic based materials such as activated charcoal or carbon is usually used.

Adsorbents are primarily used to control shallow liquid spills and MUST be compatible with the spilled material.

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Blanketing/Covering

Blanketing or covering is performed to prevent dispersion of the material.

Always consider the compatibility of the material being covered and the material covering it (Tarps, Salvage Covers, Plastic Sheeting, and Other Materials).

May also be used as a temporary mitigation tactic.

Courtesy of Rich Mahaney

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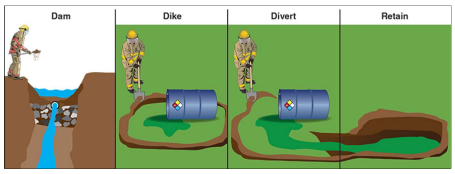
Damming, **diking**, **diverting**, and **retaining** are performed to confine or control a material.



Responders can use available earthen materials or materials carried on equipment.

Vapor suppression reduces the emissions of vapors.

Vapor dispersion directs or influences the course of airborne materials.

Pressurized water streams from hose streams or unattended master streams may be used.

After using water, responders must confine and analyze the runoff for possible contamination.

Ventilation is performed to control air movements using natural or mechanical means.

When a release occurs inside a structure, ventilation can remove and/or disperse harmful airborne particles, vapors, or gases.

When conducting negative pressure ventilation, ensure that equipment is **intrinsically safe** in a flammable atmosphere.

Positive pressure is more effective than negative pressure ventilation.

Dispersion involves breaking up or dispersing a hazardous material that is spilled on a solid or liquid surface.

Both chemicals and biological agents disperse hazardous materials and dispersal agents are used on hydrocarbon spills.

Dispersion poses a problem spreading the material over a wide area as well as other problems that may require the approval of government authorities.

Dilution is the application of water to a water soluble material to reduce the hazards.

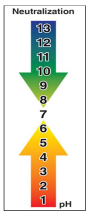
Dilution requires huge volumes of water that may create runoff issues and is frequently used during Decon operations.

Tech. Class 305-11

Dilution may be used at spills involving small amounts of corrosive materials.

Generally dilution is considered after spill control methods have been rejected.

Neutralization may be used to raise or lower the pH of corrosive materials closer to 7 (neutral).



Can also refer to any chemical reaction that reduces the hazard of the material.

Neutralization is a difficult process.

Adding too much of a neutralizer can cause a pH shift in the opposite direction.

Reactions can also release heat.

Leak control tactics are used to contain the product in its original (or another) container.

Leak control is often referred to as **containment**.

Operations Level Responders can perform leak control only under certain circumstances such as situations involving;

* Gasoline *Diesel *Liquified Petroleum Gas (LPG) *Natural Gas Fields

Operational level responders cat take *offensive actions* provided they have appropriate training, procedures, equipment, and PPE.

Operations level responders may operate ***emergency*** shut off devices on transportation containers, at fixed facilities, pipelines, and piping.

Cargo Tank Truck Shutoff Devices may vary in location, but are often behind the drivers side cab and sometimes at the rear of the tank.

Activation of these shutoffs may be as easy as pulling a handle, flipping a switch, or breaking off a fusible device.

Emergency Shut Off Locations on Cargo Tanks

MC-331 High Pressure

Corrosive liquid MC/DOT 312 tanks typically ***DO NOT*** have emergency shutoff devices.

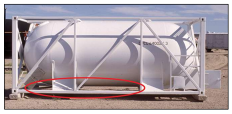
MC/DOT-306/406

Courtesy of Rich Mahaney

MC/DOT307/407

Emergency shut offs locations on intermodals

High pressure and cryogenic



Others vary by manufacturer

Courtesy of Rich Mahaney

Fixed facilities, piping, and pipelines may also have remote shutoff valves.

Remote valves may be operated without entering the hot zone.

DO NOT close valves without direction from facility or pipeline operators.

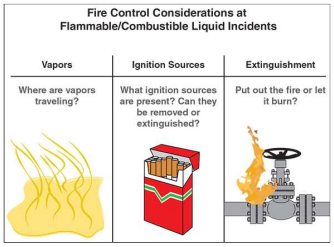
Courtesy of the Texas Commission on Fire Protection

Fire Control attempts to control damage, harm, and effects of fire at a hazmat incident.

Fire control tactics, which may be offensive or defensive, are used to **extinguish** fires and prevent ignition of hazardous materials.

Courtesy of Rich Mahaney

Consider the following factors;



Sometimes it is safer to protect exposures and let the fire burn.

Consider withdrawal as the safest tactical option due to the following;

* A threat of catastrophic container failure.
* Boiling liquid expanding vapor explosion (BLEVE) or other explosion.
* The resources needed to control the incident are unavailable.

Do not assume that relief valves are sufficient to safely relieve excess pressures.

NOTE: The ***2016 ERG*** provides **BLEVE** safety precautions on pages 368-369.

Most hazmat incidents involve **flammable and combustible liquids**, ranging from spilled fuel at car accidents to major industrial incidents involving bulk containers.

Always consider the following;

- Firefighter PPE can absorb liquids and later ignite.
- Vapors are usually heavier than air.
- Typically lighter than water and will float.
- Class B Materials; Water is ineffective at extinguishment.
- Vapors may be toxic, (Benzene is a carcinogen).

Controlling vapors is a priority at a flammable/combustible liquid spills.

Vapor suppression using firefighting foam can be effective if the foam concentrate is compatible with the hazardous material.

Mechanical foam concentrates are divided into two general categories;

* Class A fuel foams (for ordinary combustibles).
* Class B fuel foams (for flammable/combustible liquids).

We will focus on **Class B foam concentrates** used for vapor control as their are significant differences in class B foams.

Concentrates designed for hydrocarbons will not extinguish polar solvents fires, therefore do not use regular fluoroprotein and regular **aqueous film forming foam (AFFF)** on polar solvents.

The ***ERG*** can provide guidance on when to use alcohol resistant foams.

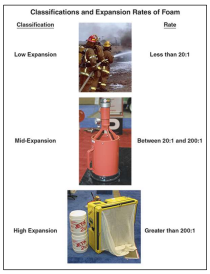
Refer to table 13.2 on page 628-629 to review foam types and applications.

Ethanol's effect on Firefighting Foam

Foam quality is measured in terms of its 25-percent- **drainage time** and its **expansion ratio**.

Drainage time is the time required for 25% or ¼ of the total liquid solution to drain from the foam.

Expansion Ratio is the volume of finished foam that results from a unit volume of foam solution.

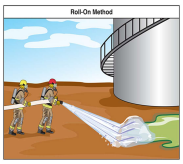


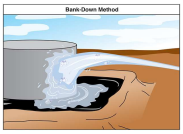
All foams have different optimal applications methods that include the following;

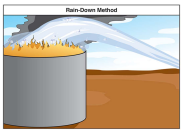
Roll-on-application method, roll the foam gently onto the material. (Bounce)

The **bank-down application** is used if the spill surrounds an obstacle, apply and let roll down the obstacle. (Deflection)

The **Rain-down method** is when the foam is sprayed into the air over the target area in a fog pattern.







Fluorprotein-type foams **ONLY** may be plunged directly into the spill.

Responders should use **air-aspirating nozzles** rather than water fog nozzles for vapor suppression.

For flammable liquid fires, non-aerated AFFF can be effective so water fog nozzles may be used.

Adequate vapor suppression relies on selection of proper foam concentrations.

REMEMBER; Finished foam is composed principally of water, so do not use on water reactive materials.

Consider the following;

* Do not use water streams in conjunction with foam.
* Ensure the material is below its boiling point.
* Do not rely on the film that precedes the foam blanket.
* Reapply periodically until foam completely covers the spill.

Flammable and combustible liquid fires may be challenging because water is not an effective extinguishing agent.

If personnel apply agents incorrectly, it may push the fuels and endanger people and exposures.

If the wrong agent is applied, responders may be placed in hazardous locations without the chance of controlling the fire.

Know the common extinguishing agents for flammable liquids;

Foam, dry chemical, and water.

Not only does the foam need to be compatible with the fuel that is burning, it must be applied at a sufficient rate to complete extinguishment.

The increased use of alternative fuels has required the introduction of specialized alcohol resistant foams.

Use **Guide 127** in the ***ERG*** for assistance with these fuels.

REMEMBER, do not extinguish the fire until the leak is controlled as well as the risks with the involvement of pressurized containers that could result in a **BLEVE**.

With the understanding that a tank failure may occur, operations may include the use of unmanned master streams when possible for tank cooling.

Since flammable gas fires in tanks pose a BLEVE risk, water streams should be deployed for maximum effective reach when containers are exposed to flame impingement.

Direct the stream (s);

* At area on the tank where there is direct flame contact.
* Along the top so water runs down both sides.
* Cool piping and steel supports to prevent collapse.

When water streams are used to disperse gas being released under pressure, the mass and velocity of the water must exceed that of the escaping gas.

Questions?

Hazardous Materials for First Responders

5th Edition

Chapter 14 - Implementing the Response:
Mission-Specific Evidence Preservation and Public Safety Sampling

When responders observe indicators of criminal activity, they must work with law enforcement agencies to preserve and protect evidence.

Operations level responders assigned to crime scene/WMD incidents must be trained in accordance with the requirements of their jurisdiction.

They should also operate under the guidance of;

- A hazardous materials technician.
- An Allied Professional.
- An emergency response plan.
- Standard operating procedures.

Responders will need to alter their response actions depending on the type of incident.

Criminal hazardous materials/WMD incidents, environmental crimes, and illicit labs differ greatly in their ***characteristics***, ***locations***, and ***associated hazards***.

Some crime scenes may include hazards such as armed individuals, booby traps, or explosives.

Hazardous device technicians or other specialists may be called to render the scene safe before the hazardous materials team proceeds.

The risks presented (as determined by intelligence, warning signs, and detection clues), and the mission being performed will determine the PPE required.

Decontamination operations must be performed in accordance with SOP's/SOG's and with care given to protect evidence.

By carrying out duties as planned, responders can achieve the goals of preserving life, stabilizing the incident, and obtaining **forensic evidence**.

Illicit drug lab operators have a vested interest in maintaining their livelihoods.

They are creators and distributors of;

- Drugs.
- Chemicals materials.
- Biological materials.
- Radioactive materials.
- Explosives.

These labs may be protected by armed guards, attack guards, and booby traps.

The following may be used in a hazmat/WMD attack;
Explosives - Bio toxins - TIC,s - Bio pathogens – radioactive - chemical warfare agents - improvised nuclear devices.

Environmental crimes involve the illegal use and disposal of hazardous substances and waste that pollute the air, water, and soil which may cause injuries and illnesses.

Incidents involving **suspicious letters and packages** may involve explosives, bio-materials, hazardous chemicals, or even radioactive materials.

Most often these involve explosives and powders.

Responders must be able to identify the **investigative authority** at hazmat/WMD crimes. Determined by the type of crime, law enforcement as well other agencies may be involved such as;

* Federal Bureau or Investigation (FBI) – for terrorist attacks.
* Drug Enforcement Administration (DEA) – crimes involving illegal drugs.
* Environmental Protection Agency (EPA) – Environmental crimes.
* Postal Inspection Service – incidents involving suspicious letters or packages.

See table 14.1 on page 656 for U.S. Federal Agency info.

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Know the **four response phases** at criminal hazmat/WMD incidents.

* **Tactical Phase** – Law enforcement removes hostile threats.
* **Operational Phase** – Life safety objectives are met, scene stabilized and secured.
* **Crime Scene Phase** – Evidence processed & packaged, scene is processed.
* **Remediation Phase** – Bring the scene back to a safe condition.

Limited public safety sampling and crime scene processing.

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Securing the scene is of utmost importance for the safety of personal that begins upon initial arrival.

The hazards and tactical requirements will determine the PPE needed. Law enforcement must be notified if it is a potential crime scene.

Give consideration for potential forensic evidence, as well as recognize and protect potential **transient evidence**.

Responders can aid in securing and protecting the scene by;

* Preventing destruction and altering of physical evidence.
* Identify all suspects or **witnesses.**
* Determine if bystanders are **witnesses.**
* Exclude unauthorized personnel from the scene.

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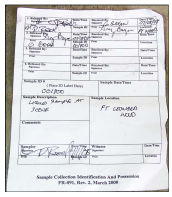
Identifying, Protection, and Preserving Potential Evidence is guided by law enforcement.

Steps include;

* Security of the scene and evidence.
* Documentation of the evidence.
* Laboratory examination.
* Transport to court.
* Discovery of the evidence.
* Custody of the evidence pending trial.
* Submission to laboratories.
* Exhibition in court.

All evidence must be handled and documented in the evidence chain by **chain of custody** procedures.

Sop's should be followed and responders must be prepared to provide the following information;

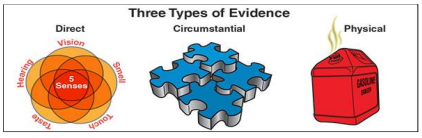


* Name, I.D. number and rank.
* Agency, date and time evidence changed possession.
* Location sample was taken.
* Incident number or **case identifiers**.
* When and to whom the sample was released.

Upon arrival at the scene, consider everything as potential evidence, try to minimizer disturbing the scene as much as possible.

Law enforcement will identify relevant items of evidence.

There are three classifications of evidence;



Securing the scene is an important step in **protecting evidence.**

* Keep unnecessary people out of the area.
* Disturb the scene as little as possible.
* Keep suspected evidence in its original position until collected if possible.
* Use barricades, traffic cones, etc. to alert that evidence is present.

It may be necessary to **protect and preserve evidence** when and where it is found until investigators arrive.

Covering evidence is one method.

Documentation can be done in many different ways and local procedures vary from jurisdiction to jurisdiction.

All scene documentation is **discoverable** in court, therefore it must be thorough and accurate. Examples of documentation include;

* Video.
* Sample logs.
* Photographs.
* Incident action plans.
* Stills.
* Site safety plan.

All documentation of actions and observations will be passed to crime scene investigators who will compile reports and other documents into a case file.

Items compiled in a case file will contain;

- Record of consent form or search warrant.
- Site safety plan.
- Incident action plan.
- Administrative logs.
- Responder observations.
- Reports such as forensic/technical reports.
- Initial responding officers documentation.
- Fire and hazmat reports.
- EMS personnel (Including hospital) documentation.
- Entry/exit documentation.
- Photographs/videos.
- Crime scene sketches/diagrams.
- Evidence documentation.

Responders are sometimes required to collect **public safety samples** to determine contaminants or suspected contaminants in support of medical treatment, to mitigate the scene, or to determine the Decon required.

At criminal hazmat/WMD events, evidence preservation and **public safety sampling** is the top priority after life preservation and hazard mitigation.

Samples may become evidence that is crucial to law enforcement for criminal investigation and prosecution.

Public safety sampling is performed to classify the material in order to determine the hazards.

They are used for risk assessments, health, Decon, and similar actions.

Hazard characterization is part of **characterizing the scene** for possible threats by identifying the unknowns and eliminating the knowns.

Prior to collecting samples, responders must field screen them to identify specific hazards prior to transport to a lab.

Before field screening, ensure that EOD technicians have cleared any potential explosives.

Responders should take actions to prevent cross contamination between samples.

The type and amount of material will determine the sampling method and equipment required.

Follow the AHJ's written protocols that outline sampling techniques, containers to be used, sealing processes to be used, and any other specific procedures.

Questions?

Hazardous Materials for First Responders

5th Edition

Chapter 15 - Implementing the Response:
Mission-Specific Illicit Laboratories

Many hazards are encounter at Illicit Labs.

Illicit Labs can be located virtually anywhere and may contain booby-traps.

Responders often discover illicit labs during responses to other types of incidents.

Responders must not only recognize the indicators for illicit labs, hazards associated with them, but develop and implement a fast accurate analysis for a successful response.

A successful response requires a plan that accounts for potential hazards and jurisdictional responsibilities.

There are special agencies that supplement the training, insight, or resources that you as a responder may not have such as;

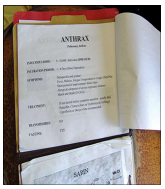
* DEA Clandestine Lab Teams.
* Local or State Law Enforcement Lab Teams.
* FBI Laboratory Forensic Response Section.

Lab operators are likely to be hostile and potentially armed. Pay attention to the following;

* Are lab operators wearing PPE?
* Presence of attack animals.
* Is a criminal affiliation running the lab?

ALWAYS don the appropriate PPE that is reflected in your SOP/SOG's.

Responders should receive an assessment of the intelligence gathered from several sources.



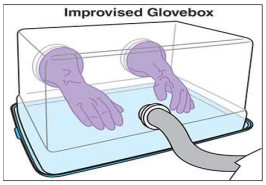
Instruction manuals, recipes, and internet resources may help identify the type of lab.

Gathering info about the lab's contents, activities, and layout as well as witness accounts will assist in forming a clear picture of the lab.

Homemade **gloveboxes** are simple to make and may indicate a potential biological lab.

We will discuss the five primary illicit (illegal) lab types;

* Drug labs.
* Explosives lab.
* Biological labs.
* Radiological labs.



Many harmful products may exist depending on the type of lab such as flammables, volatile, corrosive, toxic, or biologicals.

Both the final products as well as the materials used to make them can be very dangerous.

Always maintain good **Situational Awareness**

Responders must not turn off equipment such as electrical pumps used in cooling baths in red phosphorous **methamphetamine (meth)** labs.

Besides meth, other types of drugs produced in illicit labs are;
Ecstasy, Phenyl-2-propanone (P2P), Phencyclidine (PCP), Heroine, LSD, and Gamma-Hydroxybutyric acid (GHB).

Meth is the most common type of illicit drug lab. It is easy to make and the ingrediencies are easily available

The process of making meth is called ***cooking***, and many different recipes or methods exist. Three of the most common are;

* One/Single Bottle method (one pot method).
* Red Phosphorous (Red P) method.
* Nazi/Birch Method.

Meth labs present a danger to the **meth cook**, the community near the lab, and response personal.

Unique hazard of the Red P method is the byproduct produced, **phosphine gas**.

Table 15.2 on pages 686 thru 689 list meth sources and hazards.

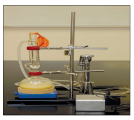
Responders must wear PPE to enter a meth lab.

Depending on the hazard present, PPE may include Chemical Protective Clothing (CPC) as well as SCBA.

Labs contain a variety of hazards including highly toxic and flammable materials.

Be familiar with the types of equipment used in drug labs.

- Condensing tubes, filters, and/or funnels/turkey basters.
- Fuel containers such as gasoline and propane cylinders.
- Glassware, heat sources, grinders, pH paper and tubing.



Condensing tubes.

Propane tank used for anhydrous ammonia.

Courtesy of Joann Hayden

Heating sources.

There are several clues to the presence of a **METH LAB**.

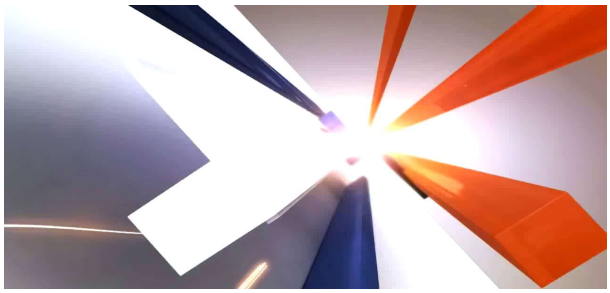
- Windows covered with plastic or tinfoil, renters who pay in cash.
- Unusual security measures and excessive trash.
- Increased activity (especially at night) or unusual structures.
- Discoloration of structures, pavement, and soil.
- Strong odors of solvents, ammonia, starting fluid, or ether.
- Iodine or chemical stained bathroom or kitchen fixtures.

Labs produce excessive waste.

For every **pound** (0.5kg) of meth produced, labs generate **6 pounds** (3kg) of waste.

Courtesy of MSA

Typically this waste is made up of a mixture of materials, presenting unique hazards that may be completely different from the hazards in the illicit lab.



Chemical warfare agents can be made in illicit labs.

Recipes may be easy to find, though material needed may not be so accessible, some are restricted.

There are clues that indicate a chemical lab;

- Military manuals and underground "cookbooks".
- Chemicals such as **organophosphate pesticides**, methyl iodide, and phosphorus trichloride.
- Sophisticated lab equipment (capable of conducting chemical reactions) and the presence of cyanides and acids.

Some explosive labs can be very variable.

After drug labs, explosive labs are the second most common type of lab encountered.

Some do not need to heat or cook their materials, lack glassware, tubing, Bunsen burners, chemical bottles, and other materials and equipment traditionally associated with labs.

Labs that make peroxide based explosives may look like a meth lab.

Explosive labs can be mistaken for drug labs because of the presence of household chemicals, and due to lack of equipment and resources required are easily established.

Recipes can be easily found on the internet, in anarchist literature as well as other sources.

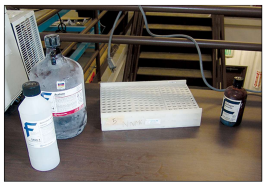
Some indicators of a possible EXPLOSIVE LAB include;

- Scales, thermometers, refrigerators, coolers, and ice baths.
- Glassware, lab equipment, blenders, grinders, mortar and pestle.

- Blasting caps, batteries, fuses and switches.
- Pipes, end caps, storage containers, shrapnel type materials.
- Strong acidic odors, explosives, military ordinances, literature.

Manufacturers use common household chemicals to make homemade explosives (HME).

- Acetone.
- Ethanal.
- Hexamine.
- Hydrogen Peroxide.
- Strong or weak acids.



The Academy sponsors a very good HME class. Check out the class listings.

Be alert to indicators of a **BIOLOGICAL LAB** such as the following equipment;

- Microscopes, growth media or **autoclaves.**
- Glove boxes, incubators, and refrigerators.

Bio labs may contain resources such as acetone, epsom salt, and sodium hydroxide.

Botox production may look like a bunch of dirt, rotten food, or garbage in a container.

Virus production requires a different type of lab setup compared to bacterial production and may include;

- T-flasks, roller bottles, well culture plates, incubators and culture rolling machines.
- Centrifuges, pipettes, disinfection materials, and live tissue matrices.

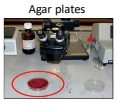
Centrifuge

Bio labs may contain sources of toxins like castor beans, antibiotics and vaccines, PPE, test animals, and growth containers.

Castor beans

PPE

Agar plates



Plastic sheeting can be used to make safety cabinets, glove boxes, or isolation areas.

Cell lysis equipment may include bench top lab roller mills and other pulverization equipment.

RADIOLOGICAL LABS may not look like traditional labs.

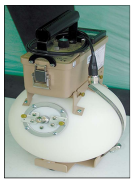
Manufacturers may use radiological materials to create a;

- Radiological Dispersal Device (RDD).
- Radiological Exposure Device(RED).
- Improvised Nuclear Device (IND).

Specially trained personal and equipment are used to mitigate and detect radiological hazards, including dose rate meters and contamination meters.

Neutron radiation is uncommon and requires specialized detection equipment.

Remember; always keep your exposure **A**s **L**ow **A**s **R**easonably **A**chievable (**ALARA**)**.**



Neutron detector

There are many indicators of radiological labs such as; trefoil symbols, illnesses or injuries consistent with rad exposure, dose rate readings, bio indicators, and presence of dosimetry to name a few. The entire list is on page 702.

Operations at illicit labs must follow SOP's and rules set forth by OSHA 1910.120.

Evidence must be preserved while mitigation is achieved and a working partnership with law enforcement.

Chapter 14 discussed responsibilities, evidence recovery and forensic operations.

Don't forget your metering/monitoring equipment

Consideration for PPE and Decon requirements should be assessed and selected based on the results of the risk-based assessment process.

Procedures must be developed for decon of weapons, ammunition and other specialized equipment.

Questions?

Thank you.

Hazardous Materials for First Responders

5th Edition

Chapter 2 - Recognizing and Identifying the Presence of Hazardous Materials

DEPARTMENT OF FIRE SERVICES
Massachusetts Firefighting Academy

1

Seven Clues to the Presence of hazardous Materials

1. Occupancy types, locations, and preincident surveys.
2. Container shapes.
3. Transportation placards, labels, and markings.
4. Other markings and colors (non-transportation).
5. Written resources.
6. Senses.
7. Monitoring and detection devices.

Always prepare for the unexpected

DEPARTMENT OF FIRE SERVICES
Massachusetts Firefighting Academy

2

Increased Risk with Higher Clue Numbers

Clue 2
Container Shapes

LOW RISK

HIGH RISK

Clue 7
Monitoring & Detection Devices

DEPARTMENT OF FIRE SERVICES
Massachusetts Firefighting Academy

3

Materials in unmarked vehicles and mixed loads could be difficult to identify

Shipping papers may not always be available.

Courtesy of Rich Mahaney

Preincident Plans

(Also known as preincident surveys and preplans)

Can simplify on site decisions, reduce oversights, confusion, and duplication of effort.

The following are some items Surveys may identify;

- Exposures (people, property, environment).
- Hazmat types (quantities, locations, dangers).
- Building features.
- Site characteristics.
- Access/Egress issues.
- Limitations of response.
- 24 hour phone #'s.
- Site/occupancy response capabilities.

Caution: Surveys are not always accurate.

Occupancy Types

An obvious location of hazardous materials

Some are sometimes not so obvious

Some may not be obvious at all

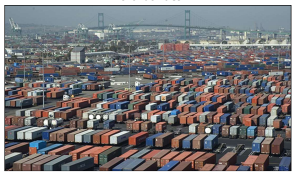
Situational Awareness

Locations

Hazmat accidents are more likely to occur in certain areas, mostly when transferred or handled.

- Roadways
- Railways
- Waterways
- Airways
- Pipelines

Port Facilities



Courtesy of U.S. Customs and Border Protection, photo by Charles Csavossy

Basic Container Shapes

Container Names by Transport Mode

Highway; Highway Cargo Trucks (Cargo Tanks, Tank Trucks).

Rail; Rail Cars (Tank Cars).

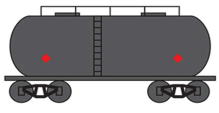
Water; Vessel Cargo Carriers (Vessels).

Multiple Modes; Intermodal Containers (Intermodals).

Containers will be studied in Chapter 5

Containers can also by classified by their capacity

Bulk **vs.** **Non-bulk Packaging**



Greater than

Solid: 882 lbs. (440 kg.)
Liquid: 119 gal. (475 L)
Gas: 1,001 lbs. (500 kg.)

Less than

Special nonbulk packages

Containers will be studied in Chapter 5

Pressure Containers

Clues to pressure containers may include the following;

Manway

Bolted Housing

Pressure Relief Device

Pressure Gauge

Containers will be studied in Chapter 5

Pressure Containers

Containers will be studied in Chapter 5

Pressure Containers

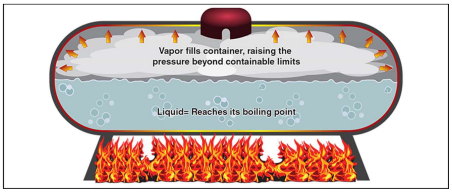
Tube Trailers

Ton Cylinder

Courtesy of Rich Mahaney

Containers will be studied in Chapter 5

Warning! Products stored in pressure containers may kill you



BLEVE Process

Cryogenic Materials

Cryogen, (sometimes called *refrigerated liquified gas)* is a gas that turns into a liquid **at or below -130˚F at 14.7psi** (101 kPa) {1.01bar}

The following are clues indicating a cryogenic container;

- Contents such as liquid oxygen (LOX), nitrogen, helium, argon, and liquified natural gas (LNG).
- Box like loading and unloading stations attached to transportation containers.

Warning! Cryogens displace oxygen causing asphyxiation, and are very cold.
Caution! Immediately remove any clothing saturated with a cryogen.

Cryogenic Containers

Tank within a tank

liquid at or below
-130˚F at 14.7 psi

Containers will be studied in Chapter 5

Liquid Containers

Many liquid containers will have some pressure due to the chemicals physical and chemical properties.

The following are clues to liquid containers;

- Flat (less rounded) ends on tanks.
- Access hatches secured with easily removable latching devices.
- Low pressure rail tank cars may have multiple fittings visible on top.
- Intermodal, flexible intermediate bulk containers, and rigid intermediate bulk containers are designed to be stacked.
- Flexible bladders filled with fluids.
- Highway cargo tanks will have oval, upside-down horseshoe, or circular ends.

Liquid Containers

Containers will be studied in Chapter 5

Liquid Containers

MC 306/DOT 406

MC 307 / DOT 407

Containers will be studied in Chapter 5

Liquid Containers

MC 312 / DOT 412
Corrosive liquid tanker

Containers will be studied in Chapter 5

Solid Containers

Many containers like drums and bottles may hold solids as well as liquids

Courtesy of Rich Mahoney

Pneumatic loading & unloading

Courtesy of David Alexander, Texas Commission on Fire Protection

Open top hoppers

WARNING! Dust explosions can kill you.
Solids can engulf you.

Containers will be studied in Chapter 5

Radioactive Materials Containers

Five basic type of containers

Excepted

Industrial

Type A

Type B

Type C

Containers will be studied in Chapter 5

Pipelines

Many hazardous materials are transported by pipelines

Pipelines transport petroleum varieties as well as liquids or gases.

WARNING! Pipelines can transport high pressure materials that can explode.

Vessel Cargo Carriers (Tankers)

Marine vessels transport over ninety percent of the worlds cargo.

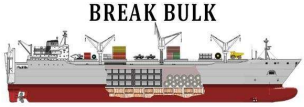
Petroleum Carriers transport crude and finished petroleum products.

Chemical Carriers transport a variety of chemical cargo.

Liquified Flammable Gas Carriers transport LNG and LP.

Vessel Cargo Carriers (Cargo Carriers)

BREAK BULK



VS

BULK

Vessel Cargo Carriers (Cargo Carriers)

Container Vessel transports cargo in intermodal containers.

Roll on/roll off Vessels have large stern and side ramps to drive vehicles off and on.

Vessel Cargo Carriers (Barges)

Towing or pushing vessels are used to move barges because they are not self propelled

Unit Loading Devices

Courtesy of John Demyan

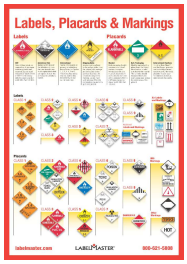
Used to consolidate cargo into a single unit for air travel.

Transportation Placards, Labels, & Markings

Label; Designed for non-bulk packages.

Placard; Designed for bulk packages.

NOTE: Labels and Placards look similar and convey similar info, but there are several unique labels for which there are no equivalent placard.



United Nations (U.N.) System

Class 1- Explosives

Class 2 - Gases

Class 3 – Flammable Liquids

Class 4 – Flammable Solids

Class 5 – Oxidizing substances & Organic Peroxides

Class 6 – Toxic and infectious substances

Class 7 – Radioactive Materials

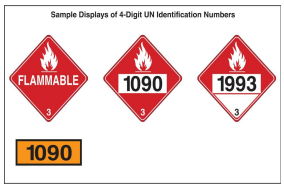
Class 8 – Corrosive Materials

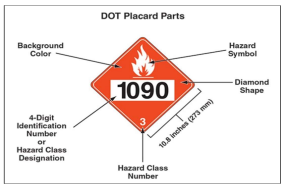
Class 9 – Miscellaneous Dangerous Substances and Articles

Will be studied these in Chapter 4.

Page 6 in the ERG

Placards and Four-digit Identification Number

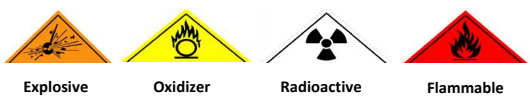




Placards are color coded by hazard class

Orange	Yellow	Red
Explosive	Oxidizer / Reactive	Flammable
White	Blue	Green
Health Hazard (Poison, Corrosive)	Water Reactive	Nonflammable Gas

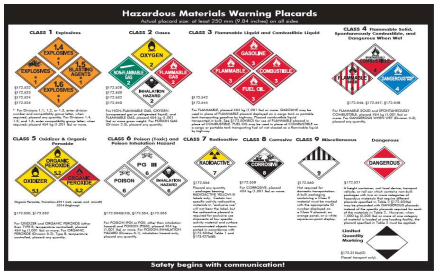
Placards may also have a hazard symbol



Explosive | Oxidizer | Radioactive | Flammable

Poisons | Corrosives | Nonflammable Gas

DOT Chart 16



Available in an APP

Mixed loads may have a Dangerous Placard

Materials Requiring Placards, ANY AMOUNT

TABLE 1

Category of material (Hazard Class or division number and additional description, as appropriate)	Placard name
1.1	EXPLOSIVES 1.1
1.2	EXPLOSIVES 1.2
1.3	EXPLOSIVES 1.3
2.3	POISON GAS
4.3	DANGEROUS WHEN WET
5.2 (Organic peroxide, Type B, liquid or solid, temperature controlled)	ORGANIC PEROXIDE
6.1 (Materials poisonous by inhalation (see §171.8))	POISON INHALATION HAZARD
7 (Radioactive Yellow III label only)	RADIOACTIVE[1]

Materials that require placarding at 1,001 lbs.

Table 2

Category of material (Hazard Class or division number and additional description, as appropriate)	Placard name
1.4	EXPLOSIVES 1.4
1.5	EXPLOSIVES 1.5
1.6	EXPLOSIVES 1.6
2.1	FLAMMABLE GAS
2.2	NON-FLAMMABLE GAS
3	FLAMMABLE
Combustible Liquid	COMBUSTIBLE
4.1	FLAMMABLE SOLID
4.2	SPONTANEOUSLY COMBUSTIBLE
5.1	OXIDIZER
5.2 (Other than organic peroxide, Type B, liquid or solid, temperature controlled)	ORGANIC PEROXIDE
6.1 (Other than materials poisonous by inhalation)	POISON
6.2	(None)
8	CORROSIVE
9	Class 9 (See §172.504(f)(9))
ORM-D	(None)

CONSUMER COMMODITY

ORM-D

Until December 31, 2013 and for the purposes of this subchapter, "ORM-D material" means a material such as a consumer commodity, cartridges, small arms or cartridges, power devices which, although otherwise subject to the regulations of this subchapter, presents a limited hazard during transportation due to its form, quantity and packaging. It must be a material for which exceptions are provided in Column (8A) of the § 172.101 Hazardous Materials Table.

Note: Though originally slated to expire December 31, 2013, the phase-out date for the ORM-D hazard class and the Consumer Commodity exception has now been extended until December 31, 2020.

(49CFR172.101/173 Subpart D)

materials of trade

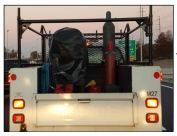


Photo by Roland LaRochelle

Protect operators and passengers:
Examples: insect repellant,
fire extinguishers, and self-contained breathing apparatus.

To support the operation or maintenance of vehicles:
Examples: spare batteries, gasoline, and engine starting fluid.

Directly support principal businesses: (not transportation):
Examples: lawn care, pest control, plumbing, welding, painting, and door-to-door sales.

Labels

Provide similar information as placards, 3.9" on point.

Class 7 Radioactive label's must always contain text.

Packages with more than one label have more than one hazard or product.

In the picture, the toxic label is the primary label while the flammable is the subsidiary.

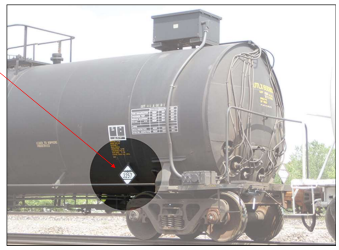
Courtesy of Rich Mahanney

Markings

Markings provide important info to first responders

In the Chart 16

Materials marked as HOT



Elevated temperature materials such as; molten sulfur and molten aluminum.

WARNING!
Treat as burn hazards.

Canadian Placards, Labels, and Markings

They are based on the U.N. Recommendations and are very similar to the U.S. Marking System with the identical nine hazard classes.

Some differences are;

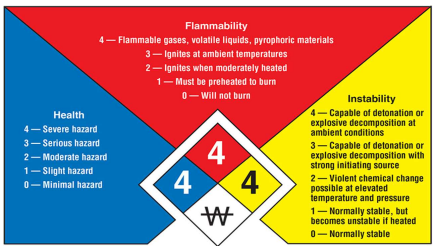
- Most Canadian transport placards do not have any signal words written.
- Labels and markings may be in both English and French.
- Canada requires a unique placard for anhydrous ammonia and inhalation hazard.
- Radiation placard may have the four digit U.N. number.

Mexican Placards, Labels, and Markings

Other Markings and Colors

- OSHA Hazard Communication Standard (Workplace).
- Manufacturers and Pesticide Labels.
- CAS Numbers.
- Globally Harmonized System.
- Military, Pipelines, and Color Codes.

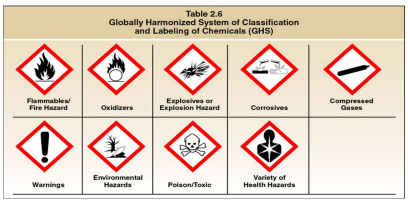
NFPA 704 System



Used in fixed facilities only

Globally Harmonized System

Promotes common, consistent criteria classifying chemicals, use of compatible labels, SDS Sheets



Page 14 in the ERG

U.S. Hazard Communication Labels and Markings

Requires employers to:

- Identify Hazards in the workplace and train employees how to recognize these hazards.
- Ensure that all containers are labeled, tagged, or marked with the identity of the substances contained in them along with the appropriate hazard warning.

Canadian Workplace Hazardous Materials Info System

Requires that hazardous products be appropriately labeled and marked.

Spells out the requirements for SDS.

Supplier and Workplace labels most commonly used.

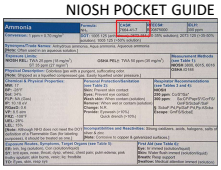
Mexican Hazard Communication System

- Equivalent to OSHA's Hazard Communication System (HCS).
- Employers ensure that hazardous chemical substances in the workplace are appropriately and adequately labeled.
- Adopts NFPA® 704 and regulated label systems as official.
- Caution symbols triangular.

Chemical Abstract Service (CAS®) Numbers

- Unique numerical identifiers assigned to various products.
- Can be used to search chemical data bases.
- Typically included on safety data sheets and other reference materials such as the NIOSH Pocket Guide.
- For all intensive purposes it is the chemicals "SS Number".

NIOSH POCKET GUIDE



Courtesy of Rich Mahaney

Military Markings

- Used on fixed facilities.
- May be on vehicles (not required).
- Not uniform.
- For security reasons, not all hazmat's will be marked.

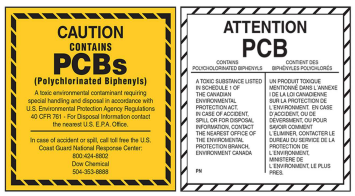
Pesticide Labels

Must contain the following;

- EPA Number or Canadian PCP Number.
- Hazard Statement(s).
- Pictogram(s).
- Precautionary Statement(s).
- Product identifiers.
- Signal Word.
- Supplier Identification.

Other Symbols and Signs

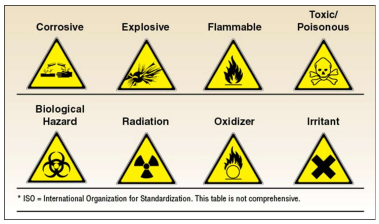
Polychlorinated biphenyl (PCB) labels



U.S. Label Canadian Label

Other Symbols and Signs

ISO Safety Symbols



ISO-3864 Standard

Color Codes

Red – Means Danger or Stop

Orange – Means Warning

Yellow – Means Caution

Green – Marks safety equipment

Blue – Marks safety information

Written Resources

Shipping Papers

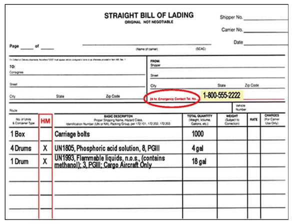
Transportation Mode	Shipping Paper Name	Location of Papers	Party Responsible
Air	Air Bill	Cockpit	Pilot
Highway	Bill of Lading	Vehicle Cab	Driver
Rail	Trainlist/Consist	Engine (or Caboose)	Conductor
Water	Dangerous Cargo Manifest	Bridge or Pilot House	Captain or Master

Shipping Papers

Sequence: (ISHP)

- **I**=Identification Number.
- **S**=Proper Shipping Name.
- **H**=Hazards Class or Division.
- **P**=Packing Group.

X is required in the HM column



Example inside front cover of the ERG

Safety Data Sheets (SDS Sheets)

Provides detailed info about a product.

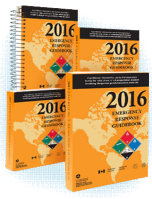
Safety Data Sheets (SDS Sheets)

16 Required Sections

1- Identification
2- Hazard(s) Identification
3- Composition/Info on Ingredients
4- First Aid Measures
5- Fire Fighting Measures
6- Accidental Release Measures
7- Handling & Storage
8- Exposure Control/ PPE
9- Physical & Chemical Properties
10- Stability & Reactivity
11- Toxicological Info
12- Ecological Info
13- Disposal Considerations
14- Transport Info
15- Regulatory Info
16- Other Info

Emergency Response Guidebook (ERG)

Developed to provide guidance to firefighters, law enforcement, and other emergency service personnel who may be the first to arrive at a transportation incident involving hazardous materials.



NOTE: Ops level responders should seek additional specific info about any material in question ***as soon as possible***.

The ERG will be covered in Chapter 3

Facility Documents

- Chemical Inventory Lists (CILs).
- Shipping and receiving documents.
- Inventory records.
- Risk management and hazard communication plans.
- Emergency response plans developed by the LEPC.


Chemical Inventory Sheet Sample

Electronic Technical Resources

Many common written resources are now available electronically

Computer-Aided Management of Emergency Operations (CAMEO): Resource designed by the National Oceanic and Atmospheric Administration (NOAA).

Wireless Information System for Emergency Responders (WISER): An electronic resource that brings a wide range of info to the responder.

911 Tool Kit: (Available only for Apple devices), provides a variety of info that may be useful for first responders.

Hazmat IQ eCharts: provides charts used to determine the appropriate response to chemical incidents.

Senses

Vision is the safest sense to use to detect a hazardous material.

Hearing can be used to detect info ***from a distance.***

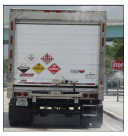
Some products cannot be detected by the senses and may cause "***olfactory fatigue***".

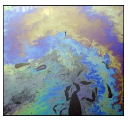
Smells, tastes, or symptoms ***reported by victims and witnesses*** may prove helpful.

Don't forget ***COMMON SENSE !!***

Be aware of **physical indicators**:

- Spreading vapor cloud, smoke, or unusual colored smoke.
- Flames, failure of PPE, dying or discolored vegetation.
- Container discoloration or bulging.
- Sick humans, dead or dying birds, animals, insects or fish.
- Discoloration of valves or piping.
- Rainbow sheen on water surfaces.
- Wavy vapors over a volatile liquid.
- Frost or ice buildup near a leak.
- Containers deformed by the force of an accident.
- Activated pressure relief devices (PRD).
- Pinging or popping of heat-or cold exposed vessels.



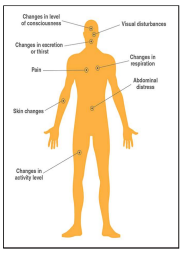


Evidence of **chemical reactions**:

- Smoking or self-igniting materials.
- Unexpected deteriorating of equipment.
- Peculiar smells and unexplained changes in ordinary materials.
- Symptoms of chemical exposure.
- Heat buildup or unusual /unexpected temp. drop (cold).
- Extraordinary fire conditions.
- Peeling or discoloration or container finish.
- Spattering or boiling of unheated materials.
- Distinctly colored vapor clouds.

Physiological signs and symptoms of chemical exposure

- Change in respiration.
- Change in level of consciousness.
- Abdominal distress.
- Change in activity level.
- Visual disturbances.
- Skin changes.
- Changes in excretion or thirst.
- Pain.



Toxins will be studied in Chapter 4

Questions?

Hazardous Materials for First Responders

5th Edition

Chapter 3 - Awareness Level Actions at Hazmat Incidents **(Notification, ERG & NIOSH)**

Courtesy of Rich Mahaney

Notification

Standard Operating Procedures (SOP's) and response plan should define the roles in the notification process.

- **Chapter 6** will address notification processes.
- **Chapter 7** will address notification requirements.

For Awareness Level personnel, notification may be as simple as calling 911. Fixed facilities may have their own internal procedures.

The actions described in this chapter are also applicable to Operations level responders.

Emergency Response Guidebook (ERG)

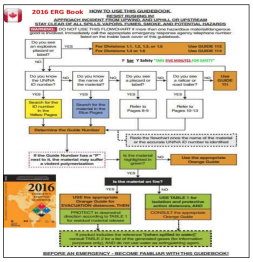
What is the ERG and what does it offer me?

- A guide to aid in quickly identifying specific or generic habits.
- Allows you to help protect yourself and the general public during the ***Initial Response Phase*** of an incident.
- Designed for use at highway or railroad incidents.
- Associated with open areas.

NOTE: The ERG does **NOT** address all possible circumstances that may be associated with a dangerous goods/hazardous materials incident

Emergency Response Guidebook (ERG)

The 2016 edition offers a flowchart on how to use the ERG on page 1.



This is a quick list of info found in the guide.

- Hazard Class System on Page 6.
- Table of Placards on Pages 8 & 9.
- Rail Car identification on Pages 10 & 11.
- Road Trailer identification on Pages 12 & 13.
- Hazard Globally Harmonized System on Pages 14 & 15.
- Identification numbers on Pages 16 thru 19.
- Pipeline hazards on Pages 20 thru 25.

Hazard Identification Numbers Displayed on Some Intermodal Containers.

The number in the top half of the panel consists of two or three digits, generally indicating the following hazards:

- ❖ Doubling of a digit indicates an intensification of that particular hazard.
- ❖ Where the hazard associated with a substance can be adequately indicated by a single digit, the digit is followed by a zero.
- ❖ A hazard identification number prefixed by the letter **"X"** indicates that the substance will react dangerously with water.

ERG Pages 16-19.

Yellow bordered section

Yellow Bordered Section provides a four-digit numerical list, followed by the guide number, than the products name.

Green Highlights indicates that the substance releases gases that are ***Toxic By Inhalation (TIH).***

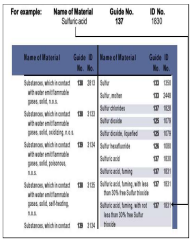
A **P** following the guide number indicates that a material ***polymerizes.***

ID No.	Guide No.	Name of Material
1086	116P	Vinyl chloride, stabilized
1087	116P	Vinyl methyl ether, stabilized
1088	127	Acetal
1089	129P	Acetaldehyde
1090	127	Acetone
1091	127	Acetone oils
1092	131P	Acrolein, stabilized
1093	131P	Acrylonitrile, stabilized
1098	131	Allyl alcohol

Blue bordered section

Blue bordered section provides an index of dangerous goods in alphabetical order.

This list displays the name of the material, followed by the assigned three digit response guide and four-digit UN/NA number.



Orange bordered section (Left-hand page)

Orange bordered section provides safety and general hazard recommendations.

The **Potential Hazards** section addresses two types of hazards, ***Health*** and ***Fire and Explosion.***

The **Public Safety** section provides general info regarding immediate *isolation of the incident* as well as *PPE*, *respiratory protection*, and *evacuation recommendations* for spills and fire.

More info on evacuation in Chapter 7, PPE in Chapter 9

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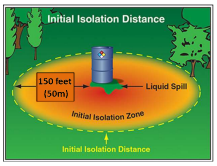
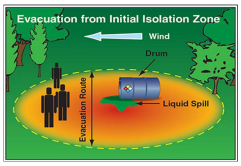


All people should be considered for evacuation



Evacuations should be conducted at right angles to the prevailing wind

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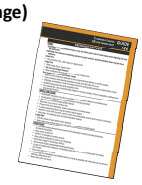
Orange bordered section (right-hand page)



The **Emergence Response** section gives recommendations in the decision making process under the following three sections;

Fire Section recommends the extinguishing agent to use on large, small, or bulk container fires.

Spill or Leak provides actions to take with regard to leaks.

First Aid provides basic steps to help victims affected by the hazmat.

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Green Bordered Section

The Tables of Initial Isolation and Evacuation Distances are broken into three tables;

Table 1, Initial Isolation and Protective Action Distances (Page 293).

Table 2, Water Reactive Materials which Produce Toxic Gases (Page 346).

Table 3, Initial Isolation and Protective Distances for Different Quantities of Six Common TIH Gases (Page 354).

Table 1; (Page 293 in the ERG), lists TIH materials by their 4-digit UN/NA ID Number.

Provides two recommendations for safe distances: ***Initial Isolation*** and ***Protective Action Distances*** for both small and large spills.

Small Spill: 55 gallons or less
Large Spill: More than 55 gallons

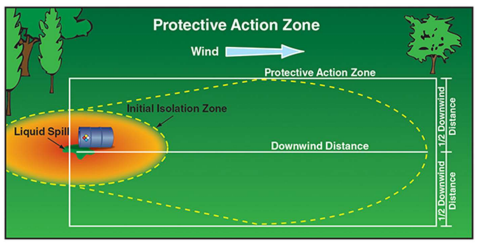


Table 2; (Page 346 in the ERG), lists water reactive materials which produce large amounts of TIH gases when spilled in water and identifies the TIH gas produces.

The materials are listed in ID number only.

If the material is **NOT** a TIH and **NOT** spilled in water, Table 1 & 2 **DO NOT** apply, use appropriate **Orange** Guide.

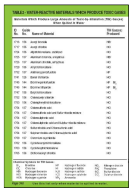
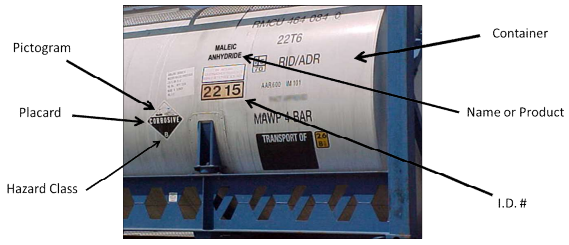


Table 3; (Page 354 in the ERG) lists Toxic Inhalation (TIH) materials that may be more commonly encounter.

- Ammonia (UN1005)
- Chlorine (UN1017)
- Ethyl Oxide (UN1040)
- Hydrogen Chloride (UN1050)(UN2186)
- Hydrogen Fluoride (UN1052)
- Sulfur/Sulphur dioxide (UN1079)

How many identification points are there?



Identify the Material & the Proper Guide #

Find the proper guide # for each material

BONUS QUESTION; Name the container and Guide #

Using the ERG, how much info can you find from this picture

Picture by Roland LaRochelle

White pages after the green sections offer the following info;

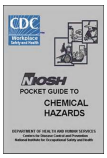
- BLEVE safety precautions on Pages 366 thru 369.
- Criminal/Terrorist use of CBRN agents on Pages 370 thru 373.
- Improvised Explosive Device (IED) safe standoff distances on Pages 374 & 375.
- Glossary on Pages 376 thru 386.
- Emergency Response Contacts on Pages 388 thru 397.

Info needed when calling response centers

- Callers name, call back phone number, and fax number.
- Location and nature of problem name and ID number of the material.
- Shipper/consignee/point of origin.
- Carrier name, railcar reporting marks, or truck number.
- Container type and size, material quantity transported or released.
- Local conditions.
- Injuries, exposures, current condition involving spills, leaks, fires, explosions, and vapor clouds etc.
- Local emergency services that have been notified.

NIOSH Pocket Guide

Information Includes;



- Chemical Structures.
- Identification Codes.
- Synonyms.
- Exposure Limits.
- Chemical & Physical Properties.
- Incompatibilities & Reactivity's.
- Respirator Selection.
- Signs and Symptoms of Exposure.
- Target Organs.
- Emergency Treatment.

Roman numeral pages

- **Table 2:** Personal Protection and Sanitation Codes.
- **Table 3:** Symbols, Code Component and Code used for Respiratory Selection.
- **Table 4:** Selection of N, R, or P Series Particulate Respirators.
- **Table 5:** Abbreviation of Exposure Routes, Symptoms, and Target Organs.
- **Table 6:** Codes for Fires Aid Data.

Materials are listed alphabetically

A **Acetaldehyde** | **Formula:** CH_3CHO | **CAS#:** 75-07-0 | **RTECS#:** AB1925000 | **IDLH:** Ca [2000 ppm]

Conversion: 1 ppm = 1.80 mg/m^3 | **DOT:** 1089 129

Synonyms/Trade Names: Acetic aldehyde, Ethanal, Ethyl aldehyde

Exposure Limits:
NIOSH REL: Ca
See Appendix A
See Appendix C (Aldehydes)
OSHA PEL†: TWA 200 ppm (360 mg/m^3)

Measurement Methods (see Table 1):
NIOSH 2018, 2538, 3507
OSHA 68

Physical Description: Colorless liquid or gas (above 69°F) with a pungent, fruity odor.

Chemical & Physical Properties:
MW: 44.1
BP: 69°F
Sol: Miscible
FI.P: -36°F
IP: 10.22 eV
Sp.Gr: 0.79
VP: 740 mmHg
FRZ: -190°F
UEL: 60%
LEL: 4.0%
Class IA Flammable Liquid

Personal Protection/Sanitation (see Table 2):
Skin: Prevent skin contact
Eyes: Prevent eye contact
Wash skin: When contam
Remove: When wet (flamm)
Change: N.R.
Provide: Eyewash
Quick drench

Respirator Recommendations (see Tables 3 and 4):
NIOSH
¥: ScbaF:Pd,Pp/SaF:Pd,Pp:AScba
Escape: GmFOv/ScbaE

Incompatibilities and Reactivities: Strong oxidizers, acids, bases, alcohols, ammonia & amines, phenols, ketones, HCN, H_2S [**Note:** Prolonged contact with air may cause formation of peroxides that may explode and burst containers; easily undergoes polymerization.]

Exposure Routes, Symptoms, Target Organs (see Table 5):
ER: Inh, Ing, Con
SY: Irrit eyes, nose, throat; eye, skin burns; derm; conj; cough; CNS depres; delayed pulm edema; in animals: kidney, repro, terato effects; [carc]
TO: Eyes, skin, resp sys, kidneys, CNS, repro sys [in animals: nasal cancer]

First Aid (see Table 6):
Eye: Irr immed
Skin: Water flush prompt
Breath: Resp support
Swallow: Medical attention immed

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Using NIOSH and ERG

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Using NIOSH and ERG

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Using NIOSH and ERG

Using NIOSH and ERG

Photos by Roland LaRochelle

Initiating Protective Actions

Protective actions including scene control can ensure your own safety and that of others.
Isolation involves physically securing and maintaining the scene by establishing the following;

- Isolation Perimeters.
- Defending in Place.
- Sheltering in Place.

Chapters 7 will dig deeper into these items

Terrorist Incidents

Terrorist and criminal incidents may differ from ordinary hazmat incidents, requiring some specific actions to be taken.

Always notify law enforcement and be alert for booby traps and secondary devices.

- Protect yourself and others.
- Prevent cross contamination.
- Avoid contacting contaminants.
- Remember, WMD agents may be deadly in small amounts.

Terrorism will be covered in Chapter 8

Questions?

Hazardous Materials for First Responders

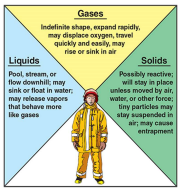
5th Edition

Chapter 4 - Identify Potential Hazards
(States of Matter, Chemical Properties & Behaviors)

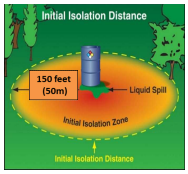
States of Matter

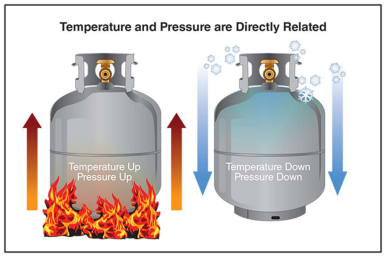
The state of matter can affect how a material behaves.

The Emergency Response Guidebook establishes separate isolation distances based solely on the involved product's state of matter.



- **SOLIDS** – 75 feet (25m).
- **LIQUIDS** – 150 feet (50m).
- **GASES** – 330 feet (100m).





Gas

Gases hazards, potentially the most dangerous for responders include;

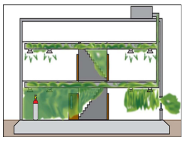
- May have an odor (such as chlorine).
- May be colorless, odorless, and/or tasteless (such as carbon monoxide).
- May be toxic (such as phosgene), corrosive (such as ammonia), or flammable (such as methane, natural gas).
- May have high pressure in excess of 15,000 psi (such as liquid helium).
- May be extremely cold upon release/or may have large expansion ratio if liquified.

Gases are difficult to contained for mitigation purposes and have different reactions depending on its transportation state. (Liquified or Compressed Gas)

They expand rapidly, some having no odor making it impossible to detect without specialized detection equipment such as a combustible gas detector.

Depending on ventilation and other factors, a Gas leak in a building may spread;

- Throughout the building.
- To other buildings.
- Through access shafts.
- Into the soil and into the street, drifting wherever the wind takes it.



Materials kept under pressure and/or temperatures higher or lower than ambient conditions may change state upon release.

The ratio that a gas will expand **(Expansion ratio)** from its liquid state is a significant factor in mitigating the hazmat incident.

Cryogenic Tank

A gaseous hazmat will present a breathing/inhalation hazard, some may also present a contact hazard.

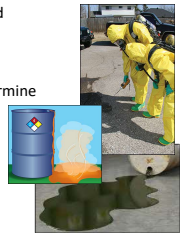
WARNING: Expanding gases can displace oxygen and create an asphyxiation hazard.

Chapter 5 will have additional info on the behavior of gases.

Liquids

Usually visible, even if their vapors are not, making it easier to detect their presence, determining the hazard area, and paths the liquid will flow.

Liquids will flow or pool according to surface contours and topography and can present a splash hazard.



Caution! Vapors from liquid spills behave like gases and monitoring and detection devices should be used to determine where they are located.
These gases may be;

- Contact Hazards
- Inhalation Hazards
- Flammable
- Corrosive and or Toxic

Solids **The least mobile of the three states of matter.**

The particle size of the solids, (dust, fumes, or powders), typically stay in place unless acted upon by exterior forces such as wind, water, and gravity that may influence their behavior.

MICRON is the unit of measure used to express particle size.

Solids may have dangerous properties such as;

- Inhalation or contact hazard.
- Small, combustible particles that, if ignited, may explode.
- Entrapment hazard in the form of loose solids in large containers.
- Flammable, reactive, radioactive, corrosive, toxic.

Solids such as dry ice and moth balls may **sublimate/sublime** and present the same hazards as liquids emitting vapors.

Physical Properties

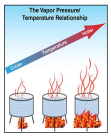
"The characteristics of a material that do not involve the chemistry or chemical nature of the material".

This section will address how the material behaves when influenced by temperature and pressure, when mixed with, or compared to another material characterized by the following physical properties;

- Vapor pressure
- Boiling point
- Melting/freezing points/sublimation
- Vapor density
- Solubility/miscibility
- Specific Gravity
- Persistence
- Appearance and odor

Vapor Pressure

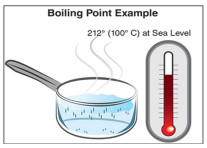
The pressure produced or exerted by the vapors released by a liquid.
(How much does the Gennie want to get out of the bottle).



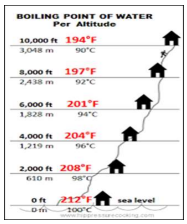
- Materials with a vapor pressure over 760 mmHg will be gases under normal conditions.
- The higher the temp. of a substance, the higher the vapor pressure will be.
- Atmospheric pressure is the baseline measurement for pressure (760 mmHg, 14.7 psi, at sea level).
- The lower the boiling point, the higher its vapor pressure will be.

Boiling Point

The temperature at which a liquid changes to a gas at a given pressure, expressed in degrees Fahrenheit (Celsius) at sea level.



Boiling point changes as altitude changes.



Boiling liquid expanding vapor explosion (BLEVE) can occur when liquid in a container is heated.

BLEVE's most commonly occur when flames contact a tank shell above the liquid level or when insufficient water is applied to keep the tank shell cool.

Melting Point/Freezing Point, Sublimation

Melting Point: Solid changes to a liquid.

Freezing Point: Liquid becomes a solid.

Sublimation: A change directly from a solid to a gas without going into a liquid.

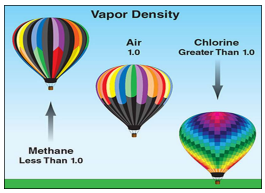
These occur at normal atmospheric pressure.

Dry ice sublimates from solid to gas

Vapor Density

The weight of gas or vapor compared to air at the same temp. and pressure

Materials with a vapor density of less than 1 will rise.
(Lighter than Air)



Materials with a vapor density greater than 1 will sink.
(Heavier than Air)

NIOSH refers to vapor density as RgasD (relative gas density).
The molecular weight of air = 28.9.

Many gases have a **vapor density** greater than 1 and will sink in relation to ambient air and will ***displace oxygen at low elevations.***

"4-H MEDIC ANNA"
Lighter than air gases

AIR

Propane
Carbon dioxide
Gasoline
Ethanol
Chlorine
Sulfur Hexafluoride

Helium (.14)
Hydrogen (.07)
Hydrogen cyanide (1.0)
Hydrogen fluoride (.34)

Methane (.55)
Ethylene (.96)
Diborane (.96)
Illuminating Gases (.6)
Carbon monoxide (.96)

Ammonia (.59)
Nitrogen (.96)
Neon (.34)
Acetylene (.9)

Solubility

Solubility in water is expressed the percentage of a material that will ***dissolve*** in water.

Jack Daniels mixes with water.

Oil does not mix with water.

Polar Solvents are water soluble liquids, combine with water and mix.

Miscibility

Miscibility is the ability of two or more gases or liquids to mix or dissolve into each other.

Immiscible is when two materials do not readily dissolve into each other.

Most hydrocarbons are immiscible and will float on water where it can ignite.

Courtesy of U.S. Coast Guard

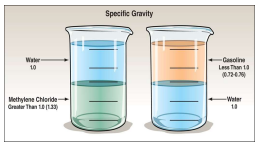
Specific Gravity

Specific Gravity is the ratio of the density of a material to that of ***water.***

The Specific Gravity of water is **1.0.**

Specific Gravity below 1.0 is lighter than water and floats.

Specific gravity above 1.0 is heavier than water and sinks.

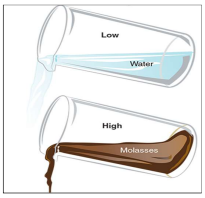


Solubility plays an important role in specific gravity.
Highly soluble materials mix or dissolve more thoroughly in water rather than sinking or floating.

Persistence and Viscosity

Persistence is the ability of a material to remain in the environment.

Viscosity is the thickness or followability of a liquid.



Appearance and Odor

Safety Data Sheets (SDS) and other reference materials such as NIOSH contain a description of the material's appearance and odor.

Obtain odor descriptions from victims, if you can detect an odor you may be **exposed.**

Odorants like **Mercaptan** may be added to some products to make them easier to detect, but some have no odor.

Courtesy of Rich Mahaney

Chemical Properties

Chemical Properties describes the nature of a material and the behaviors and interactions that occur at a molecular level.

Chemical Properties reflect the ability to burn, react, explode, or produce toxic substances hazardous to people or the environment.

This section will explain the following important chemical properties;

- Flammability
- Reactivity
- Corrosivity
- Radioactivity

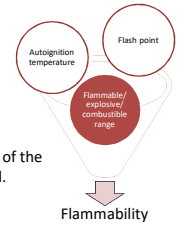
Flammability

The flammability of a material depends on three properties;

- **Flash Point:** Minimum temp. that a liquid gives off enough vapors to ignite.

Gasoline Flash Point: -45 to -50°F
Diesel Fuel FP: 120 - 140°F
Ethanol FP: 55°F

- **Autoignition Temp.:** Lowest temp. a material will ignite without a spark or flame.
- **Flammable/Explosive/Combustible Range:** Percent of the gas or vapor in air that will burn or explode if ignited.



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You must understand the following terms;

- **Fire Point:** usually a few degrees above its flash point. The temperature at which a liquid or volatile solid gives off enough vapors to support continuous burning.
- **Boiling Point:** The temperature where a liquid changes to a gas.
- **Autoignition Temperature:** The minimum temperature a fuel must be heated to initiate self-sustained combustion without a heat source. (Ignition temperature)
- **Ignition Temperature:** The temperature when a fuel spontaneously ignites.
- **Flammable Liquid:** Liquid with a flashpoint below 100°F.
- **Combustible Liquid:** Liquid with a flash point at or above 100°F and below 200°F.
- **Nonflammable:** Incapable of combustion under normal circumstances.

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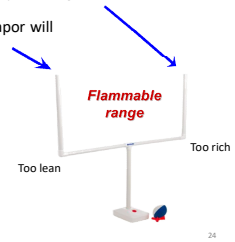
Flammable Range

Percent **of the gas or vapor concentration in air that will explode or burn if ignited.**

- **Upper Explosive Limit (UEL):** Upper limit a gas/vapor will ignite.
- **Lower Explosive Limit (LEL):** Lower limit a gas/vapor will ignite and support combustion.

- Methane = 5 – 15 %
- Propane = 2.2 – 9.5%
- Gasoline = 1.4 – 7.6%
- Carbon Monoxide = 74 – 12.5%
- Ethylene oxide = 3 – 100%



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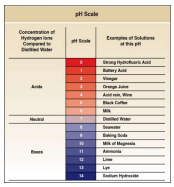
Corrosivity

Corrosives are materials that destroy living tissue and damage or destroy metals.

Corrosives are divided into two categories;

- **Acids**
- **Bases** *(alkalis or caustics)*

Effects of a corrosive on a hand



The corrosivity of acids and bases are measured or expressed in terms of **pH**.

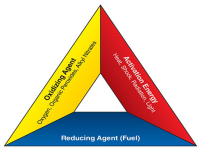
DOT and TC do not differentiate between an acid and base.

Reactivity

A chemicals relative ability to undergo a chemical reaction with itself or other materials.

Reactive Materials commonly react vigorously or violently with air, water, heat, light, each other, and other materials that may result in ***pressure buildup***, ***temperature increase***, and/or ***formation of noxious, toxic, or corrosive by products***..

Many reactions need an oxidizing agent, a reducing agent, and some kind of energy to get them started.



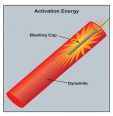
Reactivity Triangle

There are nine reactive hazard classes

- Water Reactive
- Air-Reactive
- Peroxidizable Compound
- Radioactive Material
- Highly Flammable
- Explosive
- Polymerizable
- Strong Oxidizing Agent
- Strong Reducing Agent

Activation Energy is the energy that starts a chemical reaction.

The amount of energy is dependent on the particular reaction.



The blasting cap activates the dynamite

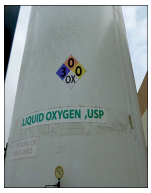
Energy sources could be; external like starting a fire with a match, waveforms like radio waves/radiation, or shock or pressure changes.

The oxidizing agent in the reactivity triangle provides the necessary oxygen for the chemical reaction.

Strong Oxidizers encourage a strong reaction, the greater the oxygen, the hotter, faster and brighter a fire will burn.

If spilled on asphalt, very little activation energy is needed to cause an explosion.

The pressure of a first responder walking on the spill may be all that is needed to start the reaction.



Liquid oxygen is a powerful oxidizer.

CAUTION: Many organic materials ignite spontaneously when they come in contact with a strong oxidizer.

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Mild Reaction

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Violent Reaction

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The process involved in **Chemical Suicides** are also a result of a reaction from the combination of materials used to rapidly displace oxygen.

Indications of **Chemical Suicides**;

- Signage is often used to warn others.
- Look for indications that a chemical reaction has been initiated.
- Typically you will find containers of household chemicals, usually acids and sulfur sources, and containers where the materials have been mixed.

If there are no evidence of chemicals or mixing containers, it is may not be a hydrogen sulfide chemical suicide.

Mixing containers and reactions.

Signage is often used to warn anyone approaching the area to use caution and notify authorities.

A tier II State Hazmat Response is the initial response level to a confirmed or potential chemical suicide where a victim is present.

State Hazmat Regional Dispatch number: 1-877-385-0822

The Massachusetts Firefighting Academy has a chemical suicide program available on-line.

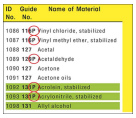
Polymerization

A chemical chain reaction where simple molecules combine to form long chain molecules.

Catalysts: Increases the rate of polymerization.
Examples; light, heat, water, acids, or other chemicals.

Inhibitor: Product added to control the reaction.

NOTE: The ERG may be the only reference material that includes polymerization, but the full list of materials may not be included.



ID No.	Guide No.	Name of Material
1086	116P	Vinyl chloride, stabilized
1087	116P	Vinyl methyl ether, stabilized
1088	127	Acetal
1089	129P	Acetaldehyde
1090	127	Acetone
1091	127	Acetone oils
1092	131P	Acrolein, stabilized
1093	130P	Acrylonitrile, stabilized
1098	131	Allyl alcohol

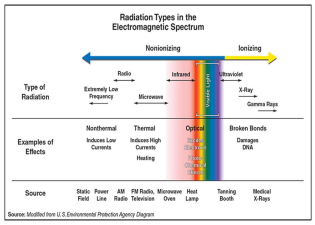
Materials designated with a ***P*** in the ERG may undergo violent polymerization.

Radioactivity

Radiation comes in different forms, some more energetic (hazardous) than others

Nonionizing Radiation:
The least energetic, such as visible light and radio waves.

Ionizing Radiation:
The most energetic (hazardous).



Four types of Radiation

Alpha

Alpha particles do not travel far in the open air and;

- Lose energy when traveling through matter.
- Do not penetrate deeply but can cause damage over a short path through human tissue.
- Usually completely blocked by the outer, dead layer of human skin.
- Not a hazard outside the body.
- Can be ***very harmful if ingested of inhaled***.

Beta

Beta particles travel farther and faster than alpha particles.

- Fast moving, positively charged protons or negatively charged electrons.
- Emitted from the atom's nucleus during radioactive decay.
- Humans are exposed from manufactured and natural sources such as tritium, carbon-14, and strontium-90.

Most hazardous when inhaled or ingested.

Gamma

High-energy photons that often accompany the emissions of alpha or beta particles from a nucleus.

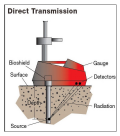
- Have neither a charge nor a mass but are penetrating.
- Can easily pass completely through the body or be absorbed by tissue.
- Gamma radiation levels depend on the isotope and activity.
- Materials such as concrete, earth, and lead can be used as shielding.

Neutron

Particles that have a physical mass but no electrical charge.

- Neutrons are very penetrating.
- Fission reactions produce neutrons and gamma radiation.
- Soil moisture density gauges, often used on construction sites are a common source of neutron radiation.
- Shielding requires large amounts of hydrogen, such as oil, water, and concrete.

Photo courtesy:
APNGA



Radioactive Material Exposure and Contamination

Radioactive materials (RAM) emit ionizing radiation.

Because radioactive materials are strictly governed, incidents are rare, but there is some concern it could be used in terrorist attacks.

Exposure: A person is near a radiation source.

Dose: Quantity of a material contacted for the purpose of measuring toxicity.

Radioactive Contamination occurs when radioactive *material* gets on surfaces, skin, etc.

Exposure does not contaminate a person, coming in contact with a **contaminant** does.

Radiation Health Hazards

Chronic Dose:

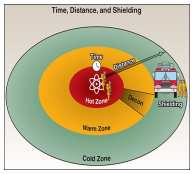
* Small amounts of radiation received over a long period of time.
* Chronic doses do not result in the same detectable health effects seen with acute doses.
* The body is better equipped to handle a chronic dose than an acute dose, and has enough time to replace dead or nonfunctioning cells with healthy cells.
* Chronic exposure to radiation can cause cancer.

Protection from Radiation

If responders note the presence of radioactive materials at an incident, radiation monitoring and detection should be initiated.

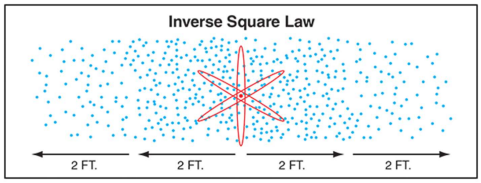
Use time, distance, and shielding to protect yourself from a radiation hazard.

ALARA Principle; As Low As Reasonably Achievable.



Chapter 11 will have more info about monitoring and detection

Doubling the distance from a radiation source divides the dose by a factor of four.



Toxicity

The degree to which a substance causes harm within the body.

Local Toxic Effect is a chemical injury at the site of contact (typically the skin and mucous membranes of the eyes, nose, mouth, or respiratory tract).

Systemic effect occurs when toxic materials are absorbed into the bloodstream and distributed to other parts of the body.

Different chemicals affect different parts of the body

The likelihood of an adverse health effect occurring and the severity of the effect depend on the following;

- Toxicity of the chemical or biological substance.
- Exposure pathway or route.
- Nature and extent of the exposure.
- Persons susceptibility to illness or injury, affected by factors such as their age or health concerns (including chronic diseases).

Appropriate PPE Must be worn at hazmat incidents

We will briefly discuss the following five toxic chemical hazard categories;

- Asphyxiant
- Irritants
- Convulsants
- Carcinogens
- Allergens and Sensitizers

Asphyxiants prevent access to sufficient volumes of oxygen.

Nitrogen is a simple asphyxiant because it can dilute and displace oxygen.

Irritants cause temporary, sometimes severe, inflammation to the eyes, skin, or respiratory system.

Courtesy of Rich Mahaney

Convulsants cause convulsions (involuntary muscle contractions), and can kill if the victim asphyxiates or succumbs to exhaustion while convulsing.

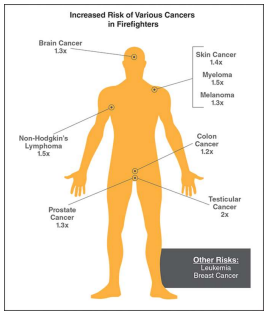
Exposure to some organophosphates pesticides may cause convulsions.

Carcinogens are known, or suspected to cause cancer.

Statistics reveal 1 in 3 firefighters will be diagnosed with cancer during their career.

Another 45% will have cancer diagnosed within seven years of retirement.

Exposure Forms



Allergens causes allergic reactions in people and animals.

Allergic reaction to tattoo ink.

Sensitizers cause a substantial proportion of exposed people or animals to develop an allergic reaction after one or more exposures.

After repeated exposure to bleach, some people become sensitized to it.

Toxic Products of Combustion

A list of common products of combustion and their effects are listed on page 175 of your text.

Three of the more common are;

- **Carbon Monoxide (CO):** a chemical asphyxiant that is a byproduct of incomplete combustion of organic (carbon-containing) materials.
- **Hydrogen Cyanide (HCN):** produced in the combustion of materials containing nitrogen, also encountered in smoke.
- **Carbon Dioxide (CO_2):** a product of incomplete combustion of organic materials.

Biological Hazards

Biological Hazards are microorganisms that may cause severe disabling disease or illness.

Many of these hazards can be transferred from blood or other bodily fluids of an infected individual.

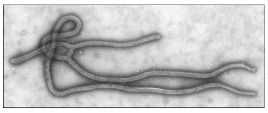
Types of biological hazards include;

- Viruses
- Bacteria
- Rickettsia
- Biological Toxins

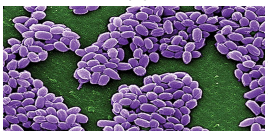
Viruses are the simplest types of microorganisms and do not respond to antibiotics.

Bacteria are microscopic, single-celled organisms that invade the tissue of humans or produce poisons.

Ebola



Anthrax



Courtesy of the CDC Public Health Image Library

Rickettsias are a specialized bacteria that spreads through the bite of infected arthropods, not through human contact.

Biological Toxins are produced by living organisms.

The organism itself is not harmful to humans.

Ticks

Courtesy of the CDC Public Health Image Library

Castor Beans

Infectious diseases are caused by the reproduction and spread of microorganisms (***pathogens***) in the body and may be ***contagious***.

Examples of diseases associated with biological hazards or threats are;

- Malaria
- Tuberculosis
- Hepatitis B
- Measles
- Ebola
- Influenza
- Typhoid

Smallpox

Biological attacks use weaponized forms of disease-causing organisms and/or their toxins such as;

* Smallpox (Virus) * Anthrax (Bacteria) * Botulism (Toxin)

Hazard Classes (Introduced in Chapter 2)

Class 1 – Explosives
Class 2 – Gases
Class 3 – Flammable liquids (and combustible liquids in the U.S.)
Class 4 – Flammable solids, spontaneously combustible, and dangerous when wet
Class 5 – Oxidizers and organic peroxides
Class 6 – Poisons, poison inhalation hazards and infectious substances
Class 7 – Radioactive Materials
Class 8 – Corrosives
Class 9 – Miscellaneous hazardous materials

Page 4 in the ERG

Class 1 - Explosives are reactive, with a great deal of potential energy that may expand and release upon activation.

Explosive placards list both a ***division number*** and a ***compatibility group letter***.

Most explosives are packaged as solids, however some are liquids such as certain ***binary explosives.***

The primary hazards of explosives are thermal and mechanical

Divisions listed on page 6 of the ERG.

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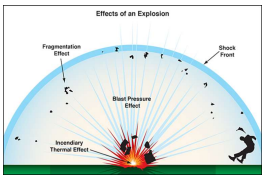
The hazards of explosives may manifest in the following conditions;

- **Blast-Pressure Wave (shock wave):** These have a positive and negative phase which both cause damage.
- **Seismic Effect:** Vibration, (similar to an earthquake) created by a blast near ground level.
- **Incendiary Thermal Effect:** The thermal heat energy creates a fireball during an explosion.
- **Shrapnel and Fragmentation:** Debris thrown during an explosion.



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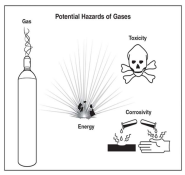
Class 2 - Gases are materials that are in a gaseous state at normal temperatures and pressures.

Gases are transported or **stored in pressure** or **cryogenic containers**.



Divisions are assigned according to the type of potential hazard posed such as;

- Heat hazard
- Asphyxiation hazard
- Cold hazard
- Mechanical hazard
- Chemical hazard

Divisions listed on page 6 of the ERG.

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Class 3 – Flammable Liquids

ignite and burn with relative ease, such as gasoline and diesel fuel spills.

While these materials are transported in liquid containers, they may give off hazardous vapors that may be toxic, corrosive, and travel to a source of ignition. Often lead to the following conditions;

- Thermal hazards
- Asphyxiation hazard
- Chemical hazards
- Mechanical hazards
- Vapors
- Environmental hazards (pollution)

Class 4 – Flammable solids, spontaneously combustible, and dangerous when wet

These materials are often solids (metals) and react violently in unexpected ways;

- Some will react to friction.
- May ignite after contact with air.
- May burn more intensely when water is used.
- May be difficult to extinguish.
- May be difficult to manage, not fully understood.

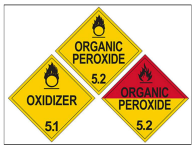
The primary hazards of Class 4 materials are; Chemical energy, Mechanical energy, Corrosivity and Toxicity.

Divisions listed on page 6 of the ERG.

Class 5 – Oxidizers and Organic Peroxides

Oxidizers vigorously support combustion, may be explosive, and may burn continuously when combined with a fuel.

Organic Peroxides are oxidizers with a specific chemical composition that makes them prone to reactivity.



They must be stored bellow the ***maximum safe storage temperature (MSST)*** in order not to reach the ***self-accelerating decomposition temperature (SADT)***

Divisions listed on page 6 of the ERG.

Class 6 – Poisons, poison Inhalation Hazard, and infectious Substances

Poisonous materials are known to be toxic to humans, avoid contact.

Inhalation hazards are toxic vapors that can be lethal if inhaled.

Infectious substances have the potential to cause disease in humans and animals.

Y-Cylinders

Secondary hazards of Class 6 materials are: Toxic Hazards, Chemical hazards from toxic and/or products of combustion, Thermal hazards (heat) from flammability and fires, Thermal hazards (heat) from substances transported in molten form.

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Cyanide

Hydrogen cyanide is produced by incomplete combustion of nitrogen and carbon containing substances (C ≡ N)

* Natural fibers (wool, silk, cotton, paper)
* Synthetic polymers (nylon, polyurethane)
* Synthetic rubber
* Melamine (resins for moldings, laminating, etc.)

Normal levels of whole blood are believed to be between 0 to 20 micrograms per deciliter (ug/dl).

Concentrations		Effect
mg/m3	PPM	
300 mg/m3	270 ppm	Immediately Lethal
200mg/m3	180 ppm	Lethal after 10 minutes
150mg/m3	135 ppm	Lethal after 30 minutes
120-150mg/m3	108-135 ppm	Highly dangerous (Fatal) after 30-60 minutes
20-40mg/m3	18-36 ppm	Light symptoms after several hours

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Class 6 Materials

Because infectious and biohazard materials are shipped in small quantities, ***they do not have a placard***, only a label.

Material known or suspected to contain a pathogen. (anthrax, hepatitis B virus, e coli.).

Marks bulk packaging containing a regulated medical waste. (Used needles/syringes, human blood, blood products, tissue, or anatomical waste).

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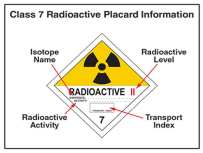
Class 7 – Radioactive Materials

Radioactive materials cannot be detected by the senses, therefore placards and labels indicate their presence, detection devices determine their presence.

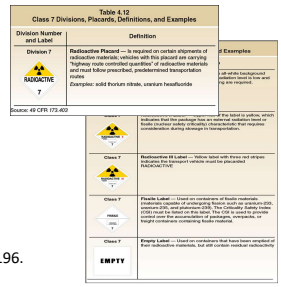
Small packages of radioactive materials must be labeled on two opposite sides with a distinctive warning label.

Class 7 labels must always contain the following;

- Isotope name.
- Radiation activity.
- Transport index (TI).
- Radioactive level.



Common Isotopes	
Industrial	**Medical**
Cs-137	Tl-201
Co-60	Tc-99m
Ir-192	I-131
Am-241	I-125
	Pd-103
	Ru-106



Pages 195-196.

Class 8 - Corrosives

Corrosives can be toxic, flammable, reactive and/or explosive.

Can be a liquid or solid that cause full thickness destruction of human skin, or a liquid that has a severe corrosion rate on steel or aluminum.

Primary hazards of Class 8 materials are chemical, toxic, thermal and mechanical that include;

- Chemical hazards such as burns.
- Toxic hazards due to exposure via all routes of entry.
- Thermal hazards (heat) including fire.
- Mechanical hazards caused by BLEVE's and chemical reactions.

Class 9 Materials

Miscellaneous dangerous goods have;

- Anesthetic, noxious, or other similar properties
- Is a hazardous substance or hazardous waste
- Is an elevated temperature material
- Is a marine pollutant

A dangerous placard may also may be used for mixed loads.

The following resources can be used to gather info needed to identify the material involved.

- Emergence Response Guidebook (ERG)
- Shippers & shipping papers
- Safety Data Sheets (SDS)
- Pipeline operators
- Computer apps like CAMEO & Wiser
- Placards and labels
- Manufactures

Survey surrounding conditions

- Potential site hazards
- Potential ignition sources
- Potential victims and exposures
- Weather and time of day
- Topography
- Info about the building, and components

Courtesy of Rich Mahaney

Emergency response centers

The ERG provides info pertaining to response centers in the white pages in both the front and back of the book.

Before you contact the emergency response center, collect as much information as possible.

Courtesy of Rich Mahaney

Mercury Vapor Experiment
Bowling Green State University

Questions?

Hazardous Materials for First Responders

5th Edition

Chapter 5 - Identify containers and predict behavior

Identify the Potential Outcomes

Once First responders collect info about the physical and chemical properties of released materials, they can;

- Determine the present hazard.
- Estimate potential harm.
- Predict how the incident may progress.

The first step in mitigating or solving any hazmat incident is ***understanding the problem***.

The **initial survey** should answer the following questions;

- Where is the incident scene in relation to population, environmental and property exposures?
- What are the hazardous materials involved?
- What kind of container holds the material?
- How is the material likely to behave?
- What is the condition of the container?
- What hazards does the site present?
- How much time has elapsed since the incident began?
- What has already been done and what resources are available?

Size-Up

The following info must be gathered and ***correctly interpreted***;

- ***Size***- Is the area changing or moving?
- ***Shape***- What is the shape of the endangered area?
- ***Exposures***- Are there people, animals, or property in the area?
- ***Physical, health, and safety hazards***- What hazards do the material and its container present?

Always verify the info if possible.

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General Hazardous Materials Behavior Model

GEMBO assists the responder to understand how a hazardous material and its container will behave, typically following a general pattern.

This model assumes that hazmat incidents have the following common elements;

- Material(s) that presents a hazard to people, environment, and property.
- Container(s) that have failed or have the potential to fail.
- Exposure, or potential exposure to people, environment, or property.

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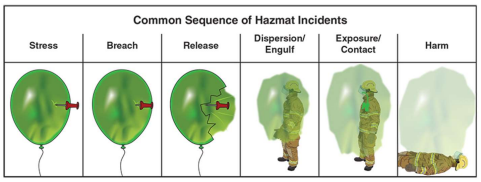
Most hazmat incidents follow a common pattern.



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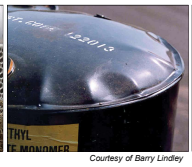
STRESS may be caused by thermal energy, chemical energy, and/or mechanical energy.

Thermal

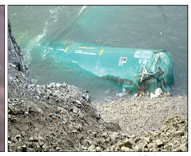
Courtesy of Barry Lindley

Chemical



Courtesy of Barry Lindley

Mechanical



Courtesy of Phil Linder

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DOT records reveal that between 2006-2014, nearly 41% of all reported hazmat incidents were attributed to container failure.

Evaluation of containers is paramount and must consider the following;

- Type of container
- Product in the container
- Type and amount of stress
- Potential duration of the stress

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When a container stresses beyond its ***limits of recovery***, it opens or ***breaches*** and releases its contents.

Types of breaches include;

- Disintegration
- Runaway cracking
- Attachments (closures) open or break
- Puncture
- Split or tear

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Disintegration | Runaway Cracking | Attachments open or break

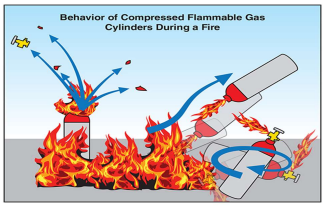


Puncture | Split or tear


Courtesy of Barry Lindley

Release

When a container fails, its contents, energy, and the container itself may release.



Pressurized flammable gas cylinders can behave like erratic rockets if they suffer a release.

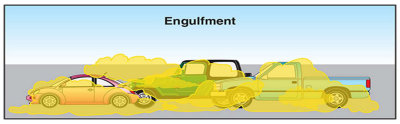
Releases are classifies according how fast they occurs;

- **Detonation:** Instantaneous and explosive release.
- **Violent rupture:** Immediate release caused by runaway cracks.
- **Rapid relief:** Fast relief through properly operating safety devices.
- **Spill/leak:** Slow release under atmospheric pressure or ***head pressure*** through holes, rips, tears, or other openings.

Dispersion and Engulfment

The type of dispersion depends on the type of release, which include;

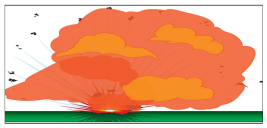
- A solid, liquid, or gas/vapor.
- Mechanical, thermal, or chemical energy and ionizing radiation.
- Product characteristic and environmental conditions.



Dispersion Patterns

The ***seven*** common dispersion patterns are;

Hemispheric

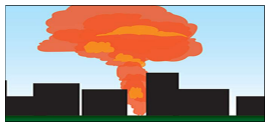


Semicircle or dome shaped pattern still partially in contact with the ground.

Cloud

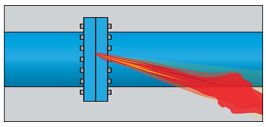
Bell shaped pattern that collectively rises above ground and/or water.

Plume



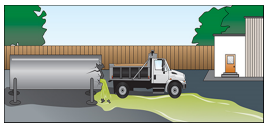
Irregularly shaped pattern where wind and/or topography influence the downrange course.

Cone



Triangular shaped pattern with a point source at the breach and a wide base downrange.

Stream



Surface following pattern of liquid that is affected by gravity and topography contours.

Pool

Three dimensional (including depth) slow flowing liquid dispersion that pools in low areas.

Irregular

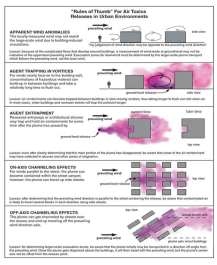
Irregular or indiscriminate deposit or a material such as caused by contaminated vehicles.

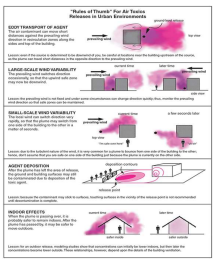
Computer software can assist in plume dispersion patterns;

- CAMEO
- ALOHA
- HPAC

Don't forget the ERG

Beware of the rule of thumb regarding plume modeling in urban areas





Page 223.

Courtesy of Los Alamos National Laboratory

Potential exposures from a hazardous materials release

Contact or impingements are associated with the following timeframes;

* Immediate
* Short-term
* Medium-term
* Long-term

People | Environment | Property



The harm, defined as injury caused by exposure, has the following three mechanisms as described in Chapter 1.

* Energy release
* Corrosivity
* Toxicity

General Container Types and Behavior

Some basic generalizations may be made about a hazmat incident based on the type(s) of container involved

- Pressure Containers
- Cryogenic Containers
- Liquid-Holding Containers
- Solid-Holding Containers

Overview of the four major types of containers and behaviors are listed on pages 227-228.

The following measurements of pressure must be understood

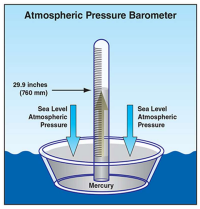
- Pounds per square inch (psi), Kilopascal (kPa), bar
- Atmospheric Pressure
- Pressure at gauge

Common Bulk Storage Tank Pressures

Type of Tank	Pressure in psi, kPa, and bar
Pressure Tanks	Above 15 psi, 103 kPa, 1.03 bar
Cryogenic Tanks	Pressures may be very low or very high
Low Pressure Tanks	Between 0.5 psi, 3.45 kPa, 0.03 bar and 15 psi, 103 kPa, 1.03 bar
Nonpressure/Atmospheric Tanks	Up to 0.5 psi, 3.45 kPa, 0.03 bar

Atmospheric Pressure measures the force exerted by weight of the atmosphere.

The greater the atmospheric pressure, the taller the column of mercury.



Pressure Containers are subject to stress when carrying materials (gases or liquids).

- **Thermal Stress, Chemical Stress, Mechanical Stress.**

Releases from ***Pressure Relief Devices*** or damaged fittings are the most common.

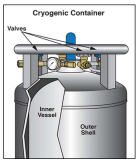
Pressure containers release rapidly expanding gases or liquids resulting in common dispersal patterns;

- **Hemispheric pattern, Cloud, Plume, Cone.**

Cryogenic Containers are durable and insulate their contents, keeping them cold.

Common stressors to cryogenic containers are; Thermal, Chemical, Mechanical.

NOTE: Venting is a function of some cryogenic containers and may not indicate a system failure.



Leaking cryogenic materials quickly boil into gases.

Expansion Ratios of several common cryogenic materials

Expansion Ratios of Common Cryogenic Materials

Gas	Nitrogen	Oxygen	Argon	Hydrogen	Helium
Boiling Point, °F	-320	-297	-303	-423	-452
Boiling Point, °C	-196	-183	-186	-253	-268
Volume Expansion	696	860	696	850	745

Typical release patterns from cryogenic containers include;

- **Hemispheric, Cloud, Plume, Pool**

Liquid-Holding Containers come in a variety of designs and construction types depending on;

- Size, mode of transportation, material contained, use, and other factors.

Liquid-Holding Containers may have the following characteristics;

- Extremely durable such as a tank car.
- Fragile such as a glass bottle.
- May fail when subjected to fire.
- Less likely to fragment when they BLEVE.
- Transport materials that polymerize.
- Uncontrolled polymerization may stress and cause container failure.
- Explosive in nature.

Solid-Holding Containers also come in a variety of designs and construction depending on the size, mode of transportation, material, use, and other factors.

Common breaches include punctures, splits, and tears and result in the following;

- Spills and leaks
- Detonation
- Violent ruptures
- Clouds, cones, irregular dispersions
- Explosions

*Courtesy of Barry Lindl

Bulk Facility Storage Tanks come in many varieties, depending on the materials stored and the pressures that need to be maintained such as;

Pressure

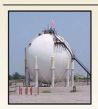
Cryogenic

Low Pressure

Nonpressure/Atmospheric

Underground Storage

Pressure

Vessel Type	Descriptions
	**Horizontal Pressure Vessel*** Have high pressures and capacities from 500 to over 40,000 gallons (1 893 L to over 151 416 L). They have rounded ends and are not usually insulated. They usually are painted white or some other highly reflective color. **Contents:** LPG, anhydrous ammonia, vinyl chloride, butane, ethane, compressed natural gas (CNG), chlorine, hydrogen chloride, and other similar products
	**Spherical Pressure Vessel** Have high pressures and capacities up to 600,000 gallons (2 271 240 L). They are often supported off the ground by a series of concrete or steel legs. They usually are painted white or some other highly reflective color. **Contents:** Liquefied petroleum gases and vinyl chloride

*It is becoming more common for horizontal propane tanks to be buried underground. Underground residential tanks usually have capacities of 500 or 1,000 gallons (1 893 L or 3 786 L). Once buried, the tank may be noticeable only because of a small access dome protruding a few inches (millimeters) above the ground.

Cryogenic

Low Pressure

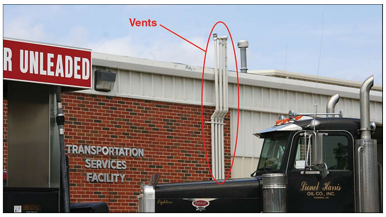
Tank Type	Descriptions
	**Dome Roof Tank** Generally classified as low pressure tanks with operating pressures as high as 15 psi (103 kPa). They have domes on their tops. **Contents:** Flammable liquids, combustible liquids, fertilizers, solvents, etc.
	**Spheroid Tank** Low pressure storage tanks. They can store 3,000,000 gallons (11 356 200 L) or more of liquid. **Contents:** Liquefied petroleum gas (LPG), methane, and some flammable liquids such as gasoline and crude oil
	**Noded Spheroid Tank** Low pressure storage tanks. They are similar in use to spheroid tanks, but they can be substantially larger and flatter in shape. These tanks are held together by a series of internal ties and supports that reduce stresses on the external shells. **Contents:** LPG, methane, and some flammable liquids such as gasoline and crude oil

Nonpressure/Atmospheric Storage Tanks

Tank Type	Descriptions
	**Covered Top Floating Roof Tank with Geodesic Dome** Floating roof tanks covered by geodesic domes are used to store flammable liquids.
	**Lifter Roof Tank** Have roofs that float within a series of vertical guides that allow only a few feet (meters) of travel. The roof is designed so that when the vapor pressure exceeds a designated limit, the roof lifts slightly and relieves the excess pressure. **Contents:** Flammable and combustible liquids
	**Vapordome Roof Tank** Vertical storage tanks that have lightweight aluminum geodesic domes on their tops. Attached to the underside of the dome is a flexible diaphragm that moves in conjunction with changes in vapor pressure. **Contents:** Combustible liquids of medium volatility and other nonhazardous materials
 Fill Connections Cover	**Atmospheric Underground Storage Tank** Constructed of steel, fiberglass, or steel with a fiberglass coating. Underground tanks will have more than 10 percent of their surface areas underground. They can be buried under a building or driveway or adjacent to the occupancy. **Contents:** Petroleum products Many commercial and private tanks have been abandoned, some with product still in them. Those tanks are presenting major problems to many communities. Rare and technically are not "tanks." First responders should be aware that some natural and manmade caverns are used to store natural gas. The locations of such caverns should be noted in local emergency response plans.

These are considered ***"Confined Spaces"***

Underground Storage Tanks



Vents for these tanks will be nearby.

Bulk Transportation Containers

Cargo Tank Trucks are highway vehicles that transport hazardous materials that include;

- Cargo Tank Trucks
  (tank motor vehicles, cargo tanks, tank trucks)
- Dry Bulk Containers
- Compressed gas tube trailers
- Mixed Load Containers
  (box trucks, dry van trucks)

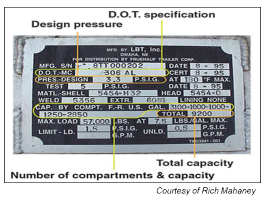
Courtesy of Rich Mahaney

Responders must recognize the clues

Ring stiffeners help to maintain the tank cross section, may be a clue to corrosive tank's.

Courtesy of Rich Mahaney

Manufacturer I.D. plates are located on the drivers side (front left) by the landing gear.



Courtesy of Rich Mahaney

High Pressure Tank Trucks (MC-331)

The following are features of the MC331;

Bobtail Tank

- Bolted Manway with inlet and outlet valves.
- White or other reflective paint with large hemispherical heads on both ends.
- Guard cage around bottom piping.
- Uninsulated single shell vessels, emergency shutoffs typically located in the left front and right rear of the tank which ,may have permanent markings.

Consider the **ERG** for isolation/evacuation distances.

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Cryogenic Tank Trucks (MC-338)

Well insulated steel or aluminum tanks with vacuum sealed shell shaving the following features;

Courtesy of Rich Mahaney

- Relief valves that may discharge vapors.
- Rounded tank with flat ends.
- Large and bulky double shell and heavy insulation.
- Loading/unloading station either at the rear or in front of the rear wheels.
- Permanent markings, emergency shutoffs on the left front and right rear.

Consider the **ERG** for isolation/evacuation distances.

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Low pressure Chemical Tank Trucks (MC-307 or DOT/TC-407)

Features of the MC-307/DOT-407 are;


Courtesy of Rich Mahaney

- Rounded or horseshoe ends.
- Stiffening rings (visible or covered).
- Rollover protection, protecting manway.
- Single or multiple compartments.
- Discharge piping at midship or rear.
- Rear or middle unloading, pressure and vacuum protection.
- Drain hose from the rollover protection down the side of the tank.
- Emergency shut offs (hydraulic or pneumatic) left front of the tank.

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Non Pressure Cargo Tank Trucks (MC-306 or DOT/TC-406)

Features of the MC-306/DOT-406 are;

Courtesy of Rich Mahanty

- Oval shape.
- Manways in rollover protection area.
- Bottom valves.
- Longitudinal rollover protection.
- Valve assembly and control box under the tank.
- Vapor recovery system on curb side and rear.
- Multiple compartments and emergency shut off systems.
- Manways and vapor recovery valves for each compartment are on top.

Corrosive Liquid Tank Trucks (MC-312 or DOT/TC-412)

Features of the MC-312/DOT-412 are;

- Small diameter round shape with stiffening rings (visible on uninsulated tanks).
- Top unloading on the rear with exterior piping extending to the bottom.
- Rollover protection around the valve assembly.
- Pressure relief device (PRD) usually located in the rollover protection.
- Discolored loading/unloading area.
- An area coated with corrosive resistant material.

The video clip that follows is of a hazardous materials transportation tank incident that happened July 21, 2011, in Sawyer, Michigan. While stopping at a truck stop, the driver saw that the tank was leaking and that pressure inside the cargo tank was higher than normal. Local police were called to the scene and a safety perimeter was established while waiting for the fire department response unit. Watch what happens next!

This is an example of a fiberglass reinforced plastic (FRP) tank carrying bleach.

This truck has an unloading area painted/coated with a corrosive resistance material.

Compressed Gas-Tube Trailers

Compressed gas tube trailers typically have the following features;

- A pressure relief device (PRD) for each tube.
- Bolted manway front or rear.
- Valves in a protective housing.
- Valves manifolded together.
- Permanent marking of the material or ownership, including proper name of the material.

Courtesy of Rich Mahaney

The following six slides are not in the book or on the test

Photo by Roland LaRochelle

What do you think is in this trailer?

This is what's in the trailer

Titan Compressed Natural Gas Truck

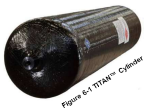


Figure 6-1 TITAN™ Cylinder

4 Composite Cylinders
43 ½ inches in Diameter
38 ½ feet long

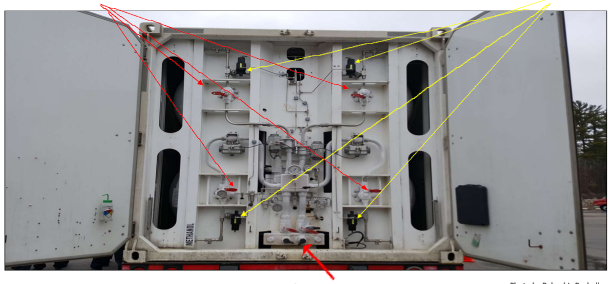
CNG Capacity of 8,886 Standard Cubic Feet.
Liquid capacity of 2,219 gallons

What do you think you will see when you open the rear doors of this truck

This is what's in the back

SHUTOFFS AT EACH CYLINDER

PRESSURE RELIEF DEVICES



Load/offload connections

Photo by Roland LaRochelle

Clues

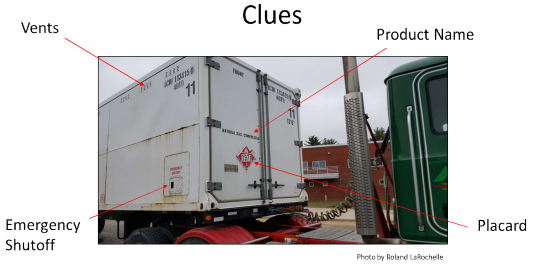


Photo by Roland LaRochelle

Don't forget the shipping papers

This was a short review of the following program;

Street Smart Portable Pipelines

Chris Christopoulos, Jr.

Watch for class scheduling on the Academy's Web Site

Dry Bulk Cargo Trailers

Transports solids, including haz-mats such as;

- Oxidizers.
- Corrosive solids.
- Cement.
- Plastic pellets.
- Fertilizers.

Courtesy of Rich Mahaney

Dry bulk cargo trailers have the following features;

- Typically not under pressure.
- Varying shapes that often include bottom valves with ***V*** or ***W*** shaped compartments.
- Rear mounted aux. powered compressors or tractor mounted PTO's.
- Air assisted loading/unloading pipes.
- Top manways.

Courtesy of Rich Mahaney

Courtesy of Barry Hurley

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Bulk Transportation Containers: Tank Cars

Tank cars are divided into three main categories;

- Low Pressure Tank Cars. (general service tank cars)
- Pressure Tank Cars.
- Cryogenic Tank Cars.

Railroad tank car capacities are much greater than cargo tank trucks.

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Pressure Tank Cars

Pressure tank cars often have the following features;

- Cylindrical.
- Non-compartmentalized.
- Metal. (steel or aluminum)
- Rounded ends. (heads)
- Top loading.
- Fittings out of sight in housing.
- May be insulated and/or thermally protected.

Courtesy of Rich Mahaney

Courtesy of Walter Schneider

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Courtesy of Barry Lindley

May be equipped with thermal insulation

May be equipped with GPS tracking.

Courtesy of Rich Mahaney

Cryogenic Liquid Tank Cars

Some features of Cryogenic Tank Cars are;

- Carry low pressure below 25 psi.
- Refrigerated liquids of **-130 and below**.
- Often have fittings for loading/offloading, pressure relief, and venting in ground level cabinets on the sides or end of the car.
- A tank within a tank type with a stainless steel inner tank and a strong outer tank. The space in between is filled with insulation in a vacuum.

Low Pressure Tank Cars

Features of low pressure tank cars are;

- Cylindrical with round ends (heads).
- At least one manway.
- Compartmentalized up to six.
- Fittings are visible at the top or bottom. (On older cars)

Trains transporting multiple low pressure tank cars containing ethanol, crude oil, and other Class 3 products may be called ***High-Hazard Flammable Trains (HHFT).***


Courtesy of Rich Mahaney

This rail car has two tanks

Many cars have visible fittings, new ones don't.

Check the specs to be sure.

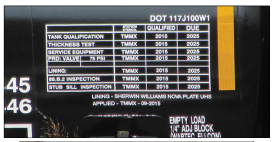

Courtesy of Rich Mahaney

High-Hazard Flammable Trains (HHFT) often carry ethanol and crude oil.

Courtesy of Rich Mahaney

Responders may encounter new DOT/TC 117 tank cars.

Courtesy of Rich Mahaney



Other Railroad Cars

Covered Hopper Cars

Courtesy of Rich Mahaney

Uncovered Hopper Car

Courtesy of Rich Mahaney

Pneumatically Unloading Hopper Cars

Courtesy of Rich Mahaney

Miscellaneous Cars

Courtesy of Barry Lindley

North American Railroad Tank Car Markings

- Reporting Marks (railcar initials and numbers).

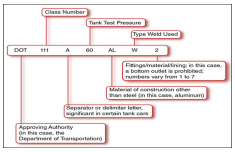
(Dedicated Tank Car)

- Capacity Stencil.

- Specification Marks.

Courtesy of Rich Mahaney

Key to tank car specifications



Intermodal Containers

Container that is used interchangeably in multiple modes of transportation.

Three general classifications of intermodal tanks are;
* Freight * Refrigerated (Reefer) * Tank

- Pressure Intermodal Tanks.
- Specialized Intermodal Tanks (cryogenic and tube modules).
- Low Pressure Intermodal Tanks (also called nonpressure).

Dry Van (box containers)

Refrigerated (reefers)

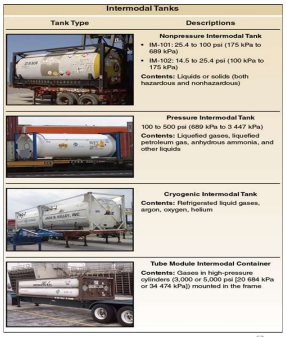
Some intermodal freight containers contain mixed loads

Loads may include hazardous and non-hazardous materials

Intermodal tank containers generally have a cylinder enclosed at both ends.

Responders may also see tube modules, cryogenic tanks, compartmentalized tanks, or other shapes.

Capacities and descriptions are listed in table 8.8 on page 267.



New intermodal container specifications include “T” code instead of “IMO codes

Pressure Intermodal Tanks

Pressure intermodal tanks are less common and are known as Spec. 51 or IMO type 5 tanks.

Working pressure of 100 to 500 psi.

Usually transport liquified gases.

Courtesy of Rich Mahaney

Low Pressure Intermodal Tanks

Also called intermodal portable tanks or IM portable tanks, these are the most common intermodal tank used.

Two most common are;

- IM 101 portable tanks
- IM 102 portable tanks

Gradually being removed from service.

Courtesy of Rich Mahaney

Specialized Intermodal Tank or Container

Cryogenic type containers built to IMO Type 7 Specs.

Tube Modules.

Dry Bulk containers.

Courtesy of Rich Mahaney

International Intermodal Markings

Reporting marks are required on intermodals in addition to placards.

Generally found on the right side of the container.

Other markings on intermodals can provide specification info.

Courtesy of Rich Mahoney

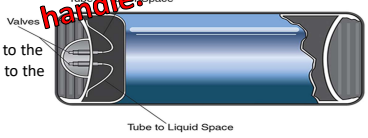
Bulk Transportation Containers: Ton Containers

Ton cylinders are typically stored on their sides.

Courtesy of Rich Mahoney

Leaks from these containers require special chemical protective clothing to handle.

Have one valve connected to the vapor space and one valve to the liquid space.



Y Cylinders/ Y Ton Cylinders

Type of compressed cylinder that can be bulk or non bulk, typically classified as bulk.

Y Cylinders have two specifications, depending on size;

Courtesy of Rich Mahoney

- **DOT/TC-3AA**; Seamless steel cylinder with a water capacity not over 1,000 lbs. and service pressure of at least 150 psig.
- **DOT/TC-3AAX;** Seamless steel cylinder with a water capacity of not less than 1,000 lbs. and a service pressure of at least 500 psig.

Other Bulk and Non-bulk Containers

- Radioactive Materials Container
- Pipelines
- Intermediate Bulk Containers
- Non Bulk Containers

Radioactive Materials Containers

- **Excepted**: Container used for transportation of materials that have very limited radioactivity and pose no risk to the public and environment.
- **Industrial:** Used for slightly contaminated clothing, Laboratory samples, and Smoke detectors.

Type A

Type B

Type C

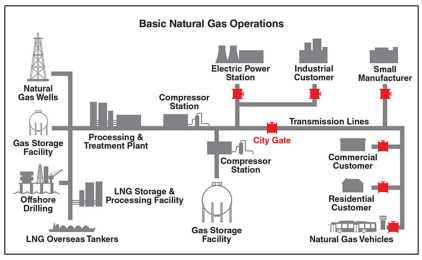
Pipelines and Piping

The over 2.5 million miles of pipelines in North America transport a variety of flammable and non flammable hazardous gases an liquids, including;

- Natural gas, Propane, and hydrogen.
- Crude oil, Diesel, and Gasoline.
- Jet Fuel, and Home Heating Oils.
- Carbon Dioxide and Anhydrous Ammonia.

A single pipeline may carry more than one type of product, separated by a pipeline pig.

Pipeline operations are complex, come in a variety of sizes and pressures.



Pipeline breaches can be caused by;

- Excavation.
- Corrosion.
- Equipment, material, joint, or weld failure.
- Operational errors.
- Natural disasters such as earthquakes or floods.
- Vehicle collisions.

Some indications of pipeline leaks and ruptures are;

- Visible vapor clouds or liquid spills.
- Hissing, roaring, or explosive sounds.
- Strong odors such as rotten eggs or petroleum smells.
- Liquid boiling up from water or soil with no obvious source.
- High pressure gas blowing out of water or soil.
- Dead vegetation or discolored snow above a pipeline right-of-way.

Pipeline markers in the U.S. and Canada provide useful information.

- Signal words ***(Caution, Warning, or Danger)***.
- Commodity Transported.
- Carriers (operators) name.
- Emergency phone number.

General considerations for responding to pipeline emergencies are found from pipeline operators and in the **ERG**, pages 23-25.

Intermediate Bulk Containers (IBC)

Either rigid or flexible portable packaging (other than a cylinder or portable tank) designed for mechanical handling.

IBC

IBC's transport a wide variety of materials and hazard classes, including;

- Aviation fuel (turbine engine).
- Gasoline, Hydrochloric Acid, Methanol.
- Toluene, Corrosive Liquids.
- Solid materials in powder, flake, or granular forms.

Flexible Intermediate Bulk Container (FIBC)

These are sometimes called;

- Bulk Bags, Bulk Sacks, Supersacks, Big Bags, or Tote Bags.

They are flexible, collapsible bags or sacks that are used to carry both solid materials and fluids.

A common sized supersack can carry the equivalent of four 55 gallon drums.

Rigid Intermediate Bulk Container (RIBC)

Typically made of steel, aluminum, wood, fiberboard, or plastic that is designed to stack.

Can contain both solid materials and liquids.

May carry liquids, fertilizers, solvents, and other chemicals having a capacity up to 400 gal. and pressures up to 100 psi.

Courtesy of Rich Mahaney

Nonbulk Packaging

Containers that are used to transport smaller quantities of hazardous materials than bulk or IBC's.

Common types of Nonbulk containers are;

- Bags
- Carboys and "Jerricans".
- Cylinders.
- Drums
- Dewar Flasks (Cryogenic Liquids).

Bags

Flexible packaging made of paper, plastic film, textiles, woven material, or other similar materials.

Bags may transport;

- Explosives and Flammable Solids.
- Oxidizers and Organic Peroxides.
- Fertilizers and Pesticides.
- Other regulated materials.

Carboys and Jerricans

Made of glass or plastic, often encased in a basket or box.

Sizes may exceed 20 gal. but 5 gal. containers are most common.

Used to transport flammable/combustible liquids, corrosives, as well as non-hazardous materials such as water.

Jerrican is another name for a rectangular carboy.

Cylinders

A pressure vessel designed for pressures higher than 40 psi. with a circular cross section.

Often used to store, transport, and dispense large volume of compressed gases.

Sizes range from small lecture bottles to large cylinders and have varying pressures.

All approved cylinders (except some that store poisons), are equipped with safety relief devices.

There is no nationally regulated color code for cylinders.

Drums

A flat ended or convex ended cylindrical packaging.

Made of metal, fiberboard, plastic, plywood, or other materials.

May have open heads or tight heads with small openings.

Capacities range up to 119 gal. but 55 gal. is the most common.

Typically metal drum carry flammables and solvents, poly drums carry corrosives.

Questions?

Hazardous Materials for First Responders

5th Edition

Chapter 6 - Planning the Response:
Identifying Action Options

Vital mistakes made in the initial response can make the difference between solving the problem and being part of it.

Courtesy of the U.S. Air Force

Predetermined procedures and SOP's/SOG's should include considerations for the following;

- Chemical responses.
- Biological responses.
- Radiological/nuclear responses.
- Explosives/explosive materials responses.
- WMD responses.
- Significant incident responses.

The initial response actions supplement, ***but do not replace,*** incident size up and other decisions based on professional judgement, evaluation, or command.

Following predetermined procedures reduces chaos on the Haz-mat scene and;

- Establishes accountability and increases command and control effectiveness.
- Helps prevent duplication of effort and uncoordinated operations.
- Describes assumption and transfer of command, communication procedures, and tactical procedures.
- Defines your role according to your training level at emergency incidents, including those involving hazardous materials.

Know your response plan and written SOP's/G's.

All hazmat incidents have ***three incident priorities***;

1- Life Safety

2- Incident Stabilization

3- Protection of property and the environment

A fourth priority, **societal restoration**, is sometimes added to this list to ensure the recovery phase of major incidents is considered from the beginning.

Priorities change, ***never risk your life*** to save property that is replaceable or cannot be saved.

Size-up and Hazard and Risk Assessment

Size-up is the recognition of clues indicating problems, or potential problems when considering all available factors that will affect an incident.

Info gained from size-up used to determine the response objectives (strategies) and action options (tactics).

Hazard and Risk Assessment is part of the size-up process.

- Focuses on the dangers, hazards, and risks presented.
- Is a continual evaluation process.
- Starts with pre-incident planning.
- Continues through the incident response operations.

All sides of the incident must be considered during an incident.

SIX Sides:

A - Side

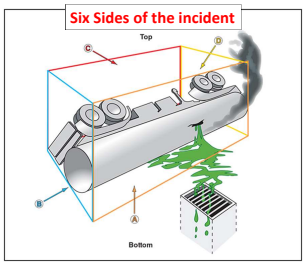
B – Side

C – Side

D – Side

Top

Bottom



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The following info needed for hazard and Risk Assessment can be obtained ***at the time the incident is reported;***

- Number and type of injuries.
- Occupancy type.
- Type of incident.
- Product and container info if available.
- Location of the incident.
- Equipment and resources responding.
- Time of day and weather.

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Once on the scene, additional pieces of info is added;

- Wind direction.
- Topography and land use.
- Presence of victims.
- Equipment access.
- Available response personal.

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Consider the following questions, if appropriate;

- What personal, equipment, and extinguishing agents are available?
- Is there private fire protection or other help available?
- What effects can the weather have?
- Are there any nearby lakes, ponds, or other waterways?
- Are there underground wires, pipelines, or utilities?
- Where are the nearest storm and sewer drains.
- What has already been done/ what would result if no action was taken?

When the incident requires a **RESCUE**, *consider the following*;

- Risk to rescuers and the ability to protect themselves.
- Probability and difficulty of the rescue.
- Capability and resources of on-scene forces.
- Possibility of explosion or other sudden release.
- Available escape routes and safe havens.
- Constraint of time and distances.

Responders can predict where the material is going given its state of matter.

Courtesy of Steve Irby, Owasso (OK) Fire Department

Responders can estimate the size of the endangered area.

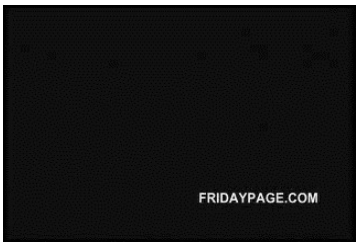
- Number of people.
- Buildings
- Property
- Environmental concerns, (sewer drains, waterways, and wells).

Situational Awareness

More than just size-up, it's a continuous process that includes;

- Size-up.
- Interpreting signs.
- Assessing what is happening over the life of the incident.
- Predicting an outcome based on a plan of action.

Courtesy of M.S.A.



Situational Awareness is sometimes referred as ***a process working at three levels;***

- **Level 1: Perception** – Perceive the situation around us.
- **Level 2: Comprehension** – Apply knowledge and experiences to perception and develop an understanding of the situation.
- **Level 3: Application** – Apply our understanding of the situation thereby predicting how and when it will change and what actions are appropriate.

Avoid the following eight factors that lead to the loss of **Situational Awareness**;

- Ambiguity.
- Distraction.
- Overload.
- Fixation.
- Complacency.
- Improper procedure.
- Unresolved discrepancy.
- Lack of comprehensive hazard surveillance.

The following actions lead to proper situational awareness;

- Maintain effective communications.
- Recognize and make others aware of any deviation from SOP's/G's or policies.
- Monitor crew members performances.
- Provide info in advance of an operation or mission.
- Identify any potential problems of existing hazards.
- Communicate the desired course of action.
- Communicate the missions status continuously.
- Evaluate the situation for any changes continuously.
- Clarify expectations of crew members continuously.

After the initial size-up, the level of the incident can be determined.

LEVEL I

- Within the capabilities of the first responder.
- Least serious and easiest to handle.
- It may pose a threat, usually not the case.
- Evacuation is limited if needed at all.

Courtesy of Rich Mahaney

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LEVEL II

- Beyond the capabilities of first responders.
- May require the services of a formal hazmat team.
- Require use chemical PPE.
- Leak control activities and other tasks requiring the responder be in close proximity of the material.

Courtesy of New South Wales Fire Brigade

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LEVEL III

- The most serious of all incidents.
- Requires multi-agency multi-jurisdictional response.
- Large scale evacuations may be required.
- Requires a collective effort from several resources to succeed.

Courtesy of the U.S. Department of Defense

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Modes of Operation

- **Nonintervention:** Allows the incident to run its course on its own.
- **Defensive:** Confinement of the hazard to a given area by diking, damming, or diverting actions.
- **Offensive:** Includes actions such as plugging a leak to control the incident.

Offensive action

Safety of the responders is the utmost concern when selecting a mode of operation.

Selection of strategic mode is based on;

- Risk to responders.
- Responders level of training.
- Balance between resources required and those available.

NONINTERVENTION mode is selected when one or more of the following circumstances exist;

- A pre-incident evaluation calls for it.
- The situation is clearly beyond the capabilities of responders.
- Explosions are imminent.
- Serious container damage threatens a massive release.

Courtesy of the U.S. Corps of Engineers

DEFENSIVE mode is selected when one of the following two circumstances exist;

- The facility or LERP calls for it based on a pre-incident evaluation of the hazards present at the site.
- Responders have the training and equipment necessary to confine the incident to the area of origin.

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OFFENSIVE mode selection could lead to the following;

- Contact with the material, requiring the responders to wear appropriate chemical protective clothing and respiratory protection.
- Operations that are beyond the scope or responsibilities for the first responders, requiring higher trained personnel.

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Planning the Initial Response

Aspects relevant to planning the initial response include;

- Response models.
- Risk based response.
- Developing the Incident Action Plan (IAP).

Using a response model can simplify the problem-solving process using;

- An information gathering or input stage.
- An implementation or output stage.
- A processing or planning stage.
- A review or evaluation stage.

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As explained in Chapter 1, ***APIE*** is a simple response model containing the basic four-step problem-solving process model elements:

- **A**nalyze the incident.
- **P**lan the initial response.
- **I**mplement the response.
- **E**valuate progress.

Other hazmat response models include;

- GEDAPER
- Eight Step Process®
- HazMatIQ®
- DECIDE
- Department of Transportation.

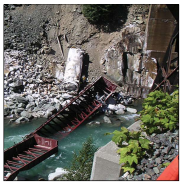
Risk Based Response

Uses information, science, and technology to mitigate a hazmat incident.

- A hierarchy of decisions needed to protect responders.
- Starts with a thorough size-up, identifying the immediate hazard so that decisions can be made in a logical and educated manner.
- Quick and efficient way to "thin slice" info and make educated, lifesaving decisions.
- Incident Action Plans (IAPs) are critical to the rapid, effective control of emergency operations.

Large scale, complex incidents may require a written IAP.

- Starts with identifying the response objectives strategy to achieve a solution to the problem.
- Command staff then selects the action options to achieve the objectives.
- Options are measured in both time and performance.
- Provides for necessary support resources.



Courtesy of Phil Linder

Elements of an IAP include;

- Strategies/incident objectives.
- Current situation summary.
- Resource assignments and needs.
- Accomplishments.
- Hazard Statement.
- Risk assessment.
- Safety plan and message.
- Protective measures.
- Current and projected weather.
- Status of injuries.
- Communication plan.
- Medical plan.

Common Response Objectives and Action Options at Hazmat Incidents

- **Response Objectives:** (Strategies) A broad statement of what needs to be done based on the following;
  - Their ability to be achieved.
  - Their ability to prevent further injuries and deaths.
  - Their ability to minimize damage within the constraints of safety, time, equipment, and personal.
- **Action Options:** (Tactics) Specific operations that must be done.

Some common response objectives at hazmat incidents are;

- Isolation.
- Notification.
- Identification.
- Protection (life safety).
- Rescue.
- Spill control/confinement.
- Leak control/containment.
- Crime scene and evidence preservation.
- Fire control.
- Recovery/termination.

Determining the Suitability of Available Personal Protective Equipment

PPE requirements may differ, depending on the following;

- Responders mission/assignment.
- Product(s) involved.
- Circumstances at the incident, like confined spaces.

PPE will be examined in greater detail in Chapter 9.

Questions?

Hazardous Materials for First Responders

5th Edition

Chapter 7 - Incident Management, **Response Objectives and Action Options**.

The third step in the APIE process is Implementing the action Plan.

A crucial step is initiating the **Incident Management System**.

- Management framework used to organize emergency incidents.
- By mandate, all emergency service organizations in the U.S. use the National Incident Management System-Incident Command System (NIMS-ICS).

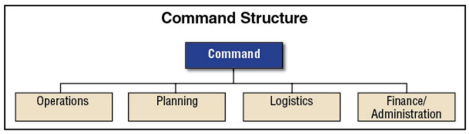
NIMS-ICS is designed to be applicable to both small and large incidents providing the following;

- Modular Organization.
- Manageable span of control.
- Organizational facilities such as command post and staging area.
- Standardized position titles.
- Integrated communications.
- Accountability of resources.

NIMS – ICS involves five major organizational functions:

Command, Operations, Planning, Logistics, and Finance/Administration.

Command has the authority to direct, order, and control resources.



Both NFPA 1026 and 1561 include more info on ICS structure and application.

Command

The basic Command organization configuration includes the following three levels;

- **Strategic Level:** The overall direction and goals of the incident.
- **Tactical Level:** Identifies the objectives that the tactical level supervisor/officer must achieve to meet the strategic goals.
- **Task Level:** The specific tasks needed to meet tactical level requirements and assigns these tasks to operational units, companies, or individuals.

Incident Commander (IC)

The IC is in overall charge of the incident and has the following responsibilities;

- Keeping an up to date report of the emergency scene.
- Establishing a command post (CP) and formulating the incident action plan (IAP).
- Coordinating and directing all incident resources to implement the plan and meet its goals and objectives.
- Informing the telecommunicator and other responders when Command is assumed or transferred.

The IC is required to perform the following functions at hazmat incidents;

- Establish site safety (scene safety) plan.
- Implement a scene security and control plan.
- Designate a Safety Officer.
- Identify the materials or conditions involved in the incident.
- Implement appropriate emergency operations.
- Ensure all responders wear appropriate PPE in restricted areas.
- Establish Decontamination Plan and operation.
- Implement post-incident procedures (Incident termination).

If the incident is large and/or complex, the IC may delegate authority to the following ***command staff*** positions;

- Safety Officer.
- Liaison Officer.
- Public Information Officer (PIO).

Safety Officer

Responsibilities include;

- Identify and monitor hazardous and unsafe conditions.
- Ensure operational and personal safety.
- Obtain briefing from the I.C.
- Review the IAP's for safety issues.
- Identify hazardous situations at the incident scene.

Safety Officer

- Participates in the prep and monitoring of entry members pre and post entry operations.
- Maintains communication with the IC, advising of any deviations from the incident safety considerations and of any dangerous situations.
- Alters, suspends, or terminates any activity that is judged to be unsafe.
- Conducts safety briefings.

At potential criminal/terrorist incidents, the safety briefing should cover;

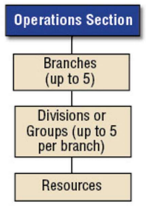
- Being alert for secondary devices.
- Do not touch or move suspicious articles.
- Do not touch or enter damp, wet, or oily areas.
- Wear full PPE and limit the number of personal entering the scene.
- Document all actions, do not take souvenirs.
- Photo or video anything suspicious.
- Do not destroy any potential evidence.
- Seek professional crime scene assistance.

Command Post (CP)

- Established at a safe location.
- Ensures the I.C. is accessible.
- Can be at a predetermined location.
- Ideally would allow the I.C. to observe the scene.
- Location is relayed to the telecommunicator/dispatcher and responders.
- Must be readily identifiable.

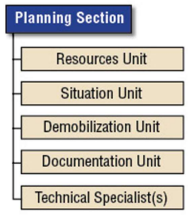
Operations Section

- Directly manages all tactical activities and priorities of the incident.
- Reports directly to the IC and is responsible for managing all operations to meet the strategic goals of the IC.
- One function is the establishment and maintenance of a staging area.



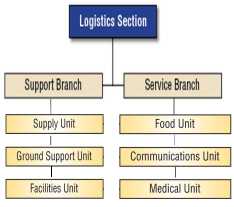
Planning Section

- Serves as the IC's clearinghouse for incidents.
- Gathers, analyzes, and processes info needed for effective decision making.
- Command uses this info to develop strategic goals and contingency plans.



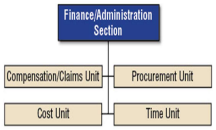
Logistic Section

- The support mechanism for the organization and is separated into two branches as shown.



Finance/Administration Section

- Established if needed.
- Often activated at large scale, long term incidents.



- Sometimes the cost analysis function is established as a Technical Specialist in the Planning Section, or addressed by the haz-mat team.

Other NIMS-ICS Organizational Functions

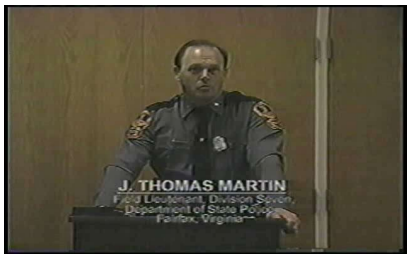
Intelligence and Information Section

- Established when WMD's or criminal activities are suspected.
- Prevents/deters potential unlawful activities, incidents, or attacks.
- Collects, processes, analyze, secures, and disseminate info.
- Identify, document, process, collect, create chain of custody, safeguard, examine, analyze, and store potential evidence.
- Conducts a thorough and comprehensive investigation.
- Serves as a conduit to provide **SITUATIONAL AWARENESS.**
- Inform and support life safety and security operations.

Incident Command Establishment and Transfer

- The first person on scene or ranking individual of the first arriving company assumes Command.
- Command is maintained until a higher ranking or more extensively trained responder arrives.
- The IC must have IMS training as well as being at the Haz-mat Operational Level.

- Before transferring Command, the IC must ensure that the new IC is capable and willing to accept Command.



Unified Command

Unified command means that all agencies that have a jurisdictional responsibility at a multi-jurisdictional incident contribute to the process by;

- Determining overall incident objectives.
- Selecting strategies.
- Accomplishing joint planning for tactical activities.
- Ensuring integrated tactical operations.
- Using all assigned resources effectively.

A ***Memorandum of Understanding (MOU)*** will help identify differences during Unified Command operations.

To avoid jurisdictional and command disputes, the following pre-incident items should be addressed;

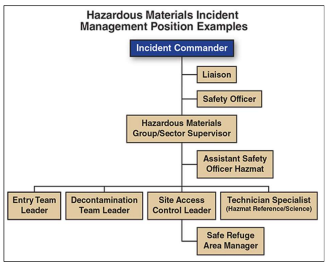
- Identify the agency/organization that will be responsible for handling response activities.
- Know what your mutual aid contracts cover.
- Plan your pre-incident coordination at the local level.

When working together, the following haz-mat survey objectives are met;

* Share vital resource information.
* Develop rapport among participants.
* Identify and pool needed resources.

Hazmat Branch

Hazmat functions will be based on the AHJ and the needs of the IC at the actual scene.



Implementing Response Objectives and Action Options

The purpose of the IAP is to develop the necessary strategy and tactics to affect a positive and safe outcome.

Some typical hazmat strategies and tactics include;

- Notification.
- Isolation/scene control.
- Hazard-control zones.
- Protection of responders.
- Protection of the public.
- Protection of the environment/property.
- Product control.
- Fire control.
- Emergency Decontamination.
- Evidence preservation.

Responders must know their role in the notification process.

The process should be described in local, district, regional, state and national emergency response plans as well as in mutual/automatic aid agreements.,

Turning to the Local Emergency Response Plan (LERP) when assistance is needed from outside agencies.

If local assets are insufficient, requests for additional assistance will be made to the State EOC, and requested from Homeland Security if needed.

Some resources that may be requested are;

- Weapons of Mass Destruction-Civil Support Team (WMD-CST).
- Disaster Medical Assistance Team (DMAT).
- Disaster Mortuary Operational Response Team (DMORT).
- National Medical Response Team WMD (NMRT-WMD).
- National Guard Force Package. (Chemical, Bio., Rad, Nuclear and high yield)
- Urban Search and Rescue (US&R) Task Force.
- Incident Management Teams (IMT).

Courtesy of Ron Jeffers

Massachusetts Hazmat/CBRNE Incident Response Activation Levels

Tier Response	*Situation*
1- TOM's Unit (ORU Optional) (5 Technicians) *Modified Tier 1 (5-7 Techs.)	Hazard & Risk Assessment or Suspicious Substance Investigation *Air Monitoring at Fire Scenes
2- TOM's Unit & ORU (1/2 Team)	Short Term Entry Operation
3- TOM's & ORU(s) (Full Team)	Long Term and/or Immediate Life Safety Risks
4- Multi Team	Major Release or extended Operation
5- Full Hazmat System, Bomb Squad, CST Team activated.	WMD or Mass Casualty Event

Phone: 1-877-385-0822

Massachusetts Chemical/Radiological/Biological Incident Response Activation Levels

Statewide Mass Decontamination Response System

Level	*Response*	*Situation*	*State HM Response*
Mass Decon C	5-7 MD's to scene, hospitals in effected & surrounding fire districts covered by MDU's.	**Major:** Shopping Mall, public arena or multiple buildings.	Tier 5
Mass Decon D	Up to 17 District MDU's to scene, most hospitals in the state covered by MDU's.	Extreme: Wide geographic area or major event.	Tier 5

Isolation and Scene Control

The isolation perimeter is a flexible construct.

- May be comprised of an inner and outer perimeter.
- May be expanded or reduced in size as needed.
- In most cases, the outcomes of an on-site risk assessment determine the initial isolation perimeter established.
- Used to control both access and egress from the incident site and establishing a hazard-control zone.

Remember: once resources are committed, it is easier to reduce the size of the perimeter than it is to extend it.

Hazard-Control Zone

The hazard-control zones provide scene control and are required at hazmat and terrorist incidents to;

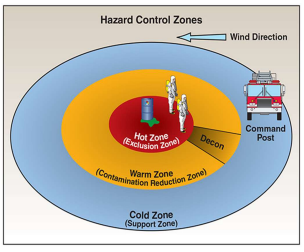
- Prevent interference by unauthorized persons.
- Help regulate first responders movements within the zones.
- Minimize contamination (including secondary contamination from victims).
- Help ensure accountability of all personal operating at large, multiagency response incidents.

Hazard-Control Zones divide the levels of hazard at an incident.

HOT ZONE
(Exclusion Zone)

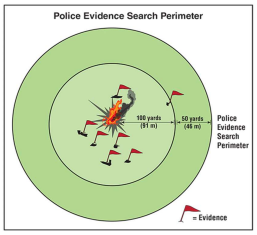
WARM ZONE
(Contamination Reduction Zone)

COLD ZONE
(Support Zone)

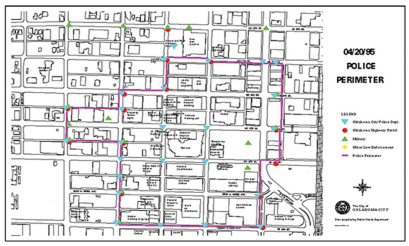


Different agencies require different control zone needs.

In the U.S., the FBI will establish a control perimeter at 1.5 times the distance of the farthest known piece of evidence.



If evidence is widespread, the evidence perimeter may encompass a very large area.



Hot Zone

The area surrounding an incident that may be contaminated where responders must have the proper training and PPE to work such as;

- SWAT Teams.
- US&R Teams.
- Haz-Mat Technicians.
- Joint Hazard Assessment Teams (JHAT).
- Mission Specific Operations.
- Bomb Technicians.

Warm Zone

Area adjoining the hot zone and extending to the cold zone.

- Serves as a buffer between the hot and cold zones.
- Decontamination location for personal and equipment exiting the hot zone.
- Monitoring and detection may be conducted around the perimeter of the warm zone.

DECON takes place in the Warm Zone

Cold Zone

Area surrounding the warm zone and is used to carry out logistical support functions such as;

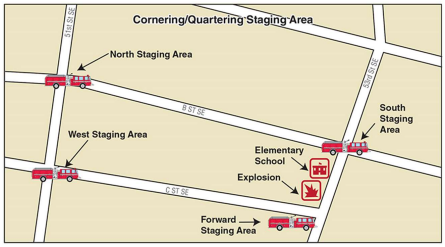
- Command Post.
- Staging Area.
- Donning/Doffing Area.
- Backup Teams.
- Research Teams.
- Logistical Support.
- Criminal Investigation Teams.
- Triage/Treatment/Rehabilitation.
- Transportation Areas.

Staging

Needs to be located in an isolated spot in a safe area where occupants cannot interfere with ongoing operations.

- Staging minimizes confusion and freelancing.
- Should be located in the cold zone.
- Safe direction of travel to the staging area should be broadcasted to all responding resources.
- Ideally, responders and equipment at terror incidents should be staged between multiple locations in case staging areas are attacked.

Some departments use a cornering/quartering staging procedure.

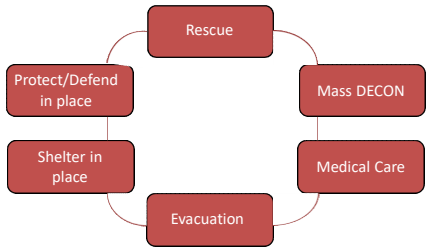


Protection of responders is the first priority at any incident.

- Stay uphill, upwind, upstream of the haz-mat.
- Wear appropriate PPE.
- Use time/distance/shielding.
- DECON responders when needed.
- Ensure accountability.
- Tracking/ID personal.
- Working as a team. (Buddy System).
- Assign Safety Officer(s).
- Putting evacuation and escape procedures in place.

Protection of the Public

The IC selects the best option:



Rescue

Factors that effect the ability to make a rescue;

- Nature of the hazmat and severity of the incident.
- Training of rescuers.
- Availability of appropriate PPE.
- Availability of monitoring equipment.
- Number of victims and their conditions.
- Time needed for a rescue.
- Tools, equipment, and other devices needed.

What is the viability of the victim?

Actions can be taken without risking contamination;

- Directing people to an area of safe refuge or evacuation point within the hot zone.
- Instructing victims to move to a less dangerous area.
- Directing contaminated victims to an isolation point or decon area.
- Giving directions to a large number of people for Mass Decon.
- Conducting searches during recon or defensive activities.
- Conducting searches at the edge of the hot zone.

Evacuation

Means to move all people from a threatened area to a safer place.

- To perform an evacuation, there must be enough time to warn people, for them to prepare to leave, and for them to leave the area by a safe route.
- Generally, if there is enough time for evacuation, it is the best protective action.
- Emergency responders should begin evacuating people who are most threatened by the incident in accordance with distances recommended by the ***ERG***, pre-incident surveys and other sources.

The IC must address the following pertaining to large scale evacuations;

- **Notification:** notify the public of the need to evacuate and where to go.
- **Transportation:** must be planned in advance.
- **Relocation Facilities and Shelters:** appropriate facilities designated.
- **Reentry:** consider how people will be allowed to return to evacuated areas.

Courtesy of FEMA News Photos; photo by Win Henderson.

Courtesy of Andrea Booher.

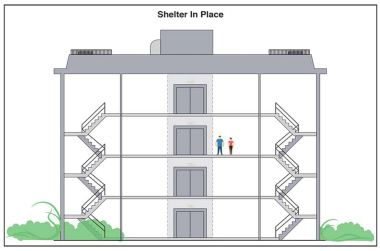
Shelter in Place

Means to direct people to go inside quickly or to stay inside a room or building until danger passes.

The decision to shelter in place may be influenced by;

- The population is unable to evacuate because of health care, detention, or educational occupancies.
- The product is spreading to rapidly to allow time to evacuate.
- The product is too toxic to risk any exposure.
- Vapors are heavier than air and people are in a high-rise or multi-level structure.

When heavier than air vapors and gases are involved, sheltering in multi-story buildings may be the safest option.



Protecting/Defending in Place

An active (offensive) role or aggressive posture to physically protect individuals in harms way.

Actions that may be taken include;

- Using hose streams to diffuse a plume.
- Securing a neighborhood or area.
- Turning off HVAC systems to minimize spread of materials.

Protection of the Environment and Property

A *defensive* control tactic.

- Includes protecting the environment and property that is threatened by an expanding incident.
- Protect exposures from fires involving Hazmat's.
- Protect the environment from harmful effects of hazmat's that are not burning.

Diking a storm drain can protect the environment.

Product Control

May become necessary when the product escapes its container.

There are two product control strategies;

- Defensive
- Offensive

Offensive product control

Product control is addressed in Chapter 13

Fire Control

Most Hazmat incidents involve flammable materials

- Strategy used to prevent ignition and/or extinguish the fire when hazardous materials are involved.
- Tactics may include using fire fighting foam or water depending on the situation and the product involved.

Fire control will be discussed in Chapter 13

Evidence Recognition and Preservation

Incidents involving WMD's or other illegal activities are crimes.

- Notify law enforcement as soon as possible.
- First responders should not collect evidence.
- Responders need to identify and preserve evidence that the investigator can collect and properly document per the AHJ.

Seemingly irrelevant things can have tremendous significance such as;

- Footprints
- Wrapping Paper
- Containers
- Location of witnesses/bystanders
- Debris Placement
- Victim Locations
- Vehicles in the Vicinity

At Illegal clandestine labs, evidence may include;

- Fingerprints.
- Weapons.
- Chemical containers.
- Notes.
- Letters.
- Papers.

Remember, life safety takes precedence over evidence.

The following actions will help preserve the scene;

- Minimize the amount of people working in the area and establish travel routes.
- Leave fatalities and their surroundings alone.
- Isolate and secure areas where evidence was found.
- Identify witnesses, victims, and the presence of evidence.
- Preserve transient physical evidence.
- Have evidence collection points near decon corridors/hot zone exits.
- At Chem. or Bio. Incidents, secure food venders/restaurants and follow all predetermined procedures.

Evaluating Progress

The evaluation is conducted throughout the incident addressing the following sections;

- Progress Reports.
- When to withdraw.
- Recovery
- Termination.

OSHA requires the following info to be provided to responders at the On-Scene Debriefing;

- Identity of the material involved.
- Potential adverse effects of exposure.
- Actions to be taken for further Decon.
- Signs and symptoms of exposure.
- Medical evaluation and treatment mechanisms.
- Exposure documentation procedures.

Questions?

Hazardous Materials for First Responders

5th Edition

Chapter 8 - Implementing the Response: **Terrorist Attacks, Criminal Activities and Disasters.**

What is Terrorism?

There are many different definitions of terrorism, however, the ***FBI*** defines terrorism as;

" The unlawful use of force against persons or property to intimidate or coerce a government, the civilian population, or any segment thereof, in the furtherance of political or social objectives."

Under this definition, all terrorist activities share the following commitments;

- Using force that involves illegal activities.
- Intimidation or coercion.
- Supporting political or social objectives.

Terrorism is designed to cause;

- Disruption
- Fear
- Panic.

Courtesy of the U.S. Department of Defense

Terrorist may want to;

- Draw attention to their cause.
- Coerce or intimidate governments into granting their demands.
- Provoke governments into repressive actions that may inspire oppressed masses to revolt.

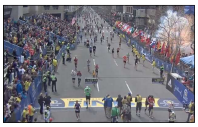
Terrorist will attack anywhere they detect vulnerability, on land, in the air, or at sea. (USS Cole)

Terrorism and Emergency Response

Terrorist incidents have similarities to non-terrorist incidents.

- All incidents have the same priorities.
- Same incident management system.
- Same risk based response procedures.

The size and type of incident plays a key role in how the response is managed.



Boston Marathon

Targeted Verses Nontargeted Incidents

Terrorist incidents are targeted;

Intent:

- Intent to cause damage, inflict harm, and kill.
- Specifically targets public and/or first responders.

Courtesy of U.S. Department of Defense

Severity & Complexity:

- May involve large numbers of casualties, large areas, and other significant dangers.

Crime Scene Management:

- Responders must preserve evidence and notify law enforcement.

Pentagon, 9-11-01

Courtesy of the U.S. Navy; photo by Journalist 1st Class Mark D. Faram

Command Structure:

- Unified Command Structure is required at most terrorist incidents.
- Law enforcement will have jurisdiction.

Some indications can cue the responder to consider the possibility of a terrorist attack.

- Report of two or more medical emergencies in a public location.
- Large numbers of people with similar medical symptoms at doctors office or emergency rooms.
- Reported explosion at public place, government building, or location with historical or symbolic significance.

CBRNE attacks at a glance

Table 8.1
Terrorist Attacks at a Glance

Chemical Attack	Biological Attack
• Victims in a concentrated area • Symptoms immediate (seconds to hours after exposure) • Symptoms very similar (SLUDGEM) • May have observable features such as chemical residue, dead foliage, dead animals/insects, and pungent odor	• Victims dispersed over a wide area • Symptoms delayed (days — weeks after exposure) • Symptoms most likely vague and flu-like • No observable features
Explosive Attack	**Radiological Attack**
• Explosion self-evident (debris field, fire, etc.) • Victims in a concentrated area • Mechanical and thermal injuries • Potential radiation and chemical agent risk — monitoring for both is necessary	• Explosion self-evident (debris field, fire, etc.) • Victims in a concentrated area • Mechanical and thermal injuries initially, radiological symptoms (if any) will likely be delayed • Radiation detected through monitoring

Page 365.

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Terrorist Targets and Types of Attacks.

- **Traditional.** (Assassinations, armed assaults, and bombings).
- **Cyber Terrorism.** (Attacks against computer systems etc.).
- **Agroterrorism.** (Attacks against agriculture).

Attacks will likely target locations where there is potential for great harm.

- Killing or injuring people.
- Causing panic and/or disruption.
- Destroying property and or demoralizing the community.

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Potential terrorist targets include;

- Mass Transportation.
- Critical infrastructure.
- Areas of Public Assembly and Recreation.
- High Profile Buildings and Locations.
- Industrial Sites.
- Educational Sites.
- Medical and Science Facilities.

Boston Marathon

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There is the fear that terrorists have the means to broaden their tactics to include the use of WMD.

Some WMD's are readily produced and/or acquires such as;

Ricin: Biological toxin made from castor beans.

Triacetone triperoxide (TATP): An explosive.

Foot and Mouth Disease: Bio agricultural.

Radiological Materials: Stolen or acquired.

Toxic Industrial Chemicals: Available everywhere.

Ricin Lab

Consensus has not been reached on which types of WMD's first responders will most likely encounter.

Given the availability of parts, ease of production and deployment, the following list is a probable WMD threat spectrum from the most likely to the least;

Bus Bomb

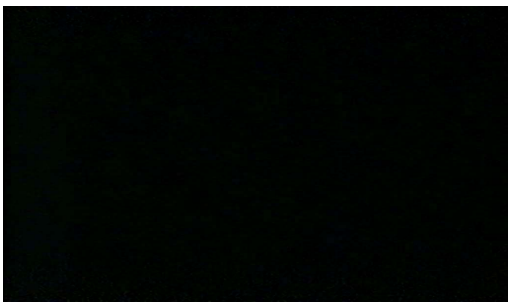
- Explosives.
- Biological Toxins.
- Industrial Chemicals.
- Biological Pathogens.
- Radiological Materials
- Military-Grade Chemical Weapons.
- Nuclear Weapons.

Secondary Attacks and Booby Traps

First responders must be alert, secondary attacks are always a possibility.

- They are often designed to affect an ongoing emergency response.
- They create more chaos and injure responders and bystanders.
- May be deployed as a diversionary tactic to route emergency responders away from the primary attack area.
- Will be hidden or camouflaged.

Acid Jar on a Door



Guidelines can help to protect against secondary devices.

- Anticipate the presence of a device at any suspicious incident.
- Conduct a visual search before moving into the area.
- Limit the number of personnel in the area.
- Avoid touching or moving anything.
- Manage the scene. (IMS, boundaries, control zones).
- Evacuate victims.
- Preserve the scene for investigators.

This replica shows shrapnel material in a guitar IED.

Booby traps and secondary devices may be concealed.

Responders should look for things that seem out of place, like this wire leading under the floor mat.

Any time a booby trap or secondary device is found or suspected, contact law enforcement and/or explosive ordinance disposal (EOD)/ bomb squad.

Explosive Attacks


Murrah Federal Building Oklahoma City 4/19/1995

A few Explosive/Incendiary attack Indicators:

- Warning or threat of an attack.
- Reports of an explosion or Accelerant odors.
- Multiple fires or explosions.
- Incendiary device or bomb components.
- Unexpected heavy burning or high temps.
- Unusually fast burning fires, colored smoke or flames.
- Presence of propane or other flammable gas cylinders.

The entire list is on page 371.

An explosive material will undergo an extremely fast, self-propagating reaction when subjected to energy.

An explosion results when a material undergoes a physical or chemical reaction that releases rapidly expanding gases.

Gases form almost instantaneously.

Pressure from the expanding gases compress the surrounding atmosphere into a shock front.

The pressure wave formed can demolish almost anything in its path.

Black Powder
(Low Explosive)

TNT (High Explosive)

There are two phases to a blast;

Negative pressure phase;

- Displaced atmosphere rushes back in to fill the vacuum left at the center of the explosion.
- Structures damaged in the initial blast can be further damaged in the negative pressure phase.
- Lasts about three times longer than the positive pressure phase.

High Explosives: Decompose rapidly in a **detonation** that can include velocities faster than the speed of sound and are placarded as DOT Division 1.1.

Examples of high explosives available for legal purchase include;

- Plastic explosives (C4 and C3).
- Nitroglycerin.
- TNT.
- Blasting Caps.
- Dynamite
- **Ammonium nitrate and fuel oil (ANFO).**

TNT Explosive

C3 Plastic Explosive

ANFO

Low Explosives: Materials that decompose rapidly but do not produce an explosive effect unless they are confined.

They **deflagrate** at a speed slower than the speed of sound and are placarded as DOT Division Number 1.4.

Examples of low explosives;

- Black Powder (used to propel bullets and fireworks).
- Pyrotechnic substances (used in fireworks & road flares).

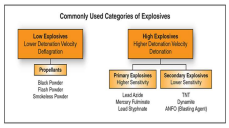
Some agencies may refer to unconfined low explosives as **incendiary materials, but some experts do not distinguish from low explosives.**

Primary and Secondary Explosives

Primary Explosives are easily initiated and highly sensitive to heat and usually used as **detonators**. Small amounts of primary explosives, even a single grain or crystal, can detonate.

Secondary Explosives are designed to detonate only under specific circumstances, usually by activation energy from a primary explosive. These are less sensitive than primary explosives to initiators such as heat and flame.

Tertiary Explosives (blasting agents) are insensitive materials based on ammonium nitrate (AN) and usually require initiation from a secondary explosive.



Commercial/Military Explosives

Normally used for such legitimate purposes as mining, demolition, excavation, construction, and military applications.

Terrorists may also use military **munitions** in explosive attacks, which may include:

- Mortars.
- Grenades.
- Antipersonnel mines.
- Surface-to-air missiles.
- Rocket propelled grenades.
- Other types of military explosives.

Homemade/Improvised Explosive Materials (HME)

Responders are **more likely** to encounter homemade or improvised explosive materials than military weapons in their day to day operations.

- Responders typically stage 300 meters (1,000 Ft) away from a suspected material.
- Improvised explosive materials are typically made by combining an oxidizer with a fuel.
- Many of these materials are fairly simple to make, require very little expertise or specialized equipment.

NOTE: Page 374 of the ***2016 Emergency Response Guidebook*** provides and IED safe Stand-Off Distance Table.

Peroxide-Based Explosives

Peroxide-Based Explosives are made by mixing concentrated hydrogen peroxide, acetone, and either hydrochloric or sulfuric acid.

These include acetone peroxide (Triacetone triperoxide or TATP) and hexamethylene triperoxide diamine (HMTD).

Both TATP and HMTD are unstable during the manufacturing process as well as a finished product.

TATP looks like many common, white, powdery substances, but it may be very unstable. Specialized equipment is not required for the manufacturing of TATP and HMTD so they can be produced almost anywhere.

Improvised Explosive Devices (IEDs)

Chlorate-Based Explosives

Some IEDs may contain chlorate-based oxidizers that commonly take the form of a white crystal or powder that must be mixed with a fuel source. Many manufacturing processes and many products use chlorates, including printing, dying, steel, weed killer, matches, and explosives.

Nitrate-Based Explosives

Some IEDs may contain nitrate-based oxidizers, and some may already have a fuel source included such as black and smokeless powder.

Depending on sophistication, IEDs are relatively easy to make and can be constructed in almost any location and setting.

They are homemade, not commercially manufactured.

Usually constructed for a specific target and can be contained within almost any object

Ordinary objects such as door openers, wires, and other electronic components and be used to build IEDs.

IEDs often include nails, tacks, broken glass, bolts, and other items that will cause additional shrapnel damage and fragmentation injuries.

The only limitation to the design and implementation of IEDs is the bombers imagination.

Courtesy of the U.S. Army; photo by Spc. Ben Brody.

"Be cautious, IEDs can be placed anywhere"

IED Types Categorized by Containers

Bomb types, based on the outer container, can include features similar to the following descriptions;

Pipe Bombs–The most common type of IED found in the US.

Satchel, backpack, knapsack, duffel bag, briefcase, or box bombs –
These containers may be filled with explosives or an explosive device because it is common to see people carrying backpacks or other types of bags.
These come in any style, color, or size (even as small as a cigarette pack).

Plastic Bottle Bombs: Soda bottles filled with a material such as dry ice or a combination of reactive materials that will react rapidly.

Be careful around plastic containers containing multilayered liquids and containers with white or gray liquids with cloudy appearance.
Do not attempt to move or open plastic bottle bomb, once initiated, they can detonate at anytime.

Manufacturers may use materials such as;

- Pool Chemicals.
- Dry Ice.
- Alcohol.
- Acid.
- Aluminum.
- Toilet Bowl Cleaner.
- Drain Cleaner.
- Driveway Cleaners.

Other Types of IEDs

Fireworks; Some may be modified or combined to make more powerful explosives.

M-Devices: Most common are 5/8 X 1 ½ inch M-80s.

Carbon Dioxide (CO_2) Grenades: Known as *crickets* have a small range but create a great deal of destruction.

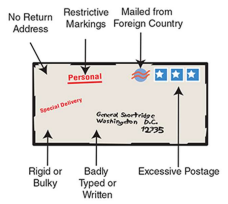
Tennis Ball Bombs: Filled with an explosive mixture, ignited by a simple fuse.

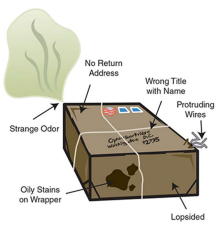
Other objects that seem to have an ordinary purpose, such as fire extinguishers.

Courtesy of August Vernon

Mail, Package, or Letter Bombs

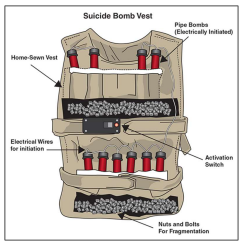
A package or letter may be used to conceal the explosive device or material.





Person-Borne Improvised Explosive Devices (PBIEDs)

Clothing can conceal a bomb



Courtesy of August Vernon

- Actions indicating a strong determination to get a target.
- Repeated visit to a high risk location during the recon/target acquisition phase.
- Placing items in a location that seems out of place or that arouse curiosity.

Alone and nervous.

Loose and/or bulky clothing.

Exposed wires (possibly through a sleeve).

Rigid mid-section (explosive device or a rifle).

Tightened hands (may be holding a detonation device).

Never approach a suspected or confirmed suicide bomber who is injured or diseased, clear and isolate the area and observe with binoculars.

Personal from an **explosive ordinance disposal (EOD)** unit will conduct the first approach, possibly using a bomb disposal robot.

In Massachusetts, a combination or State Police Bomb and Haz-Mat Technicians form JHART Teams.

Courtesy of the U.S. Marine Corps; photo by Sgt. Lukas M. Atwell

Vehicle-Borne Improvised Explosive Devices (VBIEDs)

VBIEDs can cause massive destruction and can be placed anywhere in a vehicle.

Courtesy of the U.S. Air Force; photo by Master Sgt. Robert R. Hargreaves Jr.

Here are a few Indicators of a possible VBIED;

- Preincident intel, 911 calls, or suspiciously parked vehicle.
- Abandoned vehicle in public assembly, tourist, pedestrian area.
- Vehicle parked between/against/close to building support columns.
- Vehicle appears to be weighed down, has stolen or no plates.

See pages 386-388 for a complete list.

Response to Explosive/IED Events

Only certified technicians should touch, move, defuse, or handle explosive devices.

Courtesy of the U.S.Air Force; photo by Airman Matthew Flynn

Responders should do the following;

- Use intrinsically safe communication equipment.
- Note unusual activities/persons and report observations.
- Limit personnel exposure until the risk is eliminated.

WARNING: Avoid staging near gardens, garbage bins or other vehicles that conceal explosives.

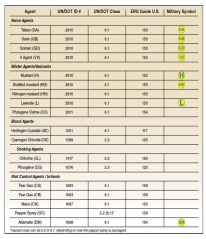
Chemical Attacks

The deliberate release of a toxic gas, liquid, or solid that can poison people and the environment.

Chemical Agents and **Toxic Industrial Materials (TIMs)** may be used by terrorists.

Table 8.3 on page 390 as well as the **ERG** will provide UN/DOT ID numbers/hazard classes/and additional info for some common chemical warfare agents.

Letters in () represent military designations.

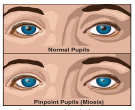


Agent	UN/DOT ID #	UN/DOT Class	ERG Guide U.S.	Military Symbol
Nerve Agents				
Tabun (GA)	2810	6.1	153	GA
Sarin (GB)	2810	6.1	153	GB
Soman (GC)	2810	6.1	153	GD
V Agent (VX)	2810	6.1	153	VX
Blister Agents/Vesicants				
Mustard (H)	2810	6.1	153	HD
Distilled mustard (HD)	2810	6.1	153	HD
Nitrogen mustard (HN)	2810	6.1	153	
Lewisite (L)	2810	6.1	153	L
Phosgene Oxime (CX)	2811	6.1	154	
Blood Agents				
Hydrogen Cyanide (AC)	1051	6.1	117	
Cyanogen Chloride (CK)	1589	2.3	125	
Choking Agents				
Chlorine (CL)	1017	2.3	124	
Phosgene (CG)	1076	2.3	125	
Riot Control Agents / Irritants				
Tear Gas (CS)	1693	6.1	159	
Tear Gas (CN)	1693	6.1	159	
Mace (CN)	1697	6.1	153	
Pepper Spray (OC)		2.2 9/17	159	
Adamsite (DM)	1698	6.1	154	DM

Hazard class can be 2.2 or 6.1, depending on how the pepper spray is packaged.

Page 389-390

Here are some indicators;



Exposure to chemical agents may cause miosis.

- Warning or threat of an attach or received intel.
- Presence of haz-mats or lab equipment that is not relevant to the occupancy.
- Intentional release of hazardous materials.
- Unexplained patterns of sudden onset of similar nontraumatic illnesses or deaths.
- Unexplained odors/tastes that are out of character for the surroundings.
- Multiple individuals exhibiting unexplained skin, eye, or airway irritation.

The entire list is on pages 390-391.

SLUDGEM or DUMBELS

SLUDGEM

- **S**alivation (drooling)
- **L**acrimation (tearing)
- **U**rination
- **D**efecation
- **G**astrointestinal upset/aggravation (cramping)
- **E**mesis (vomiting)
- **M**iosis (pinpoint pupils) or muscular twitching/spasms

DUMBELS

- **D**efecation
- **U**rination
- **M**iosis or Muscular twitching
- **B**ronchospasm (wheezing)
- **E**mesis
- **L**acrimation
- **S**alvation

TIMs used as chemical weapons may be identified through traditional methods such as;

- Identification of occupancy types and locations.
- Container shapes.
- Hazardous materials placards, labels, and markings.
- Written resources.
- Sensory indicators.
- Use of monitoring and detection devices.

Nerve Agents

The most toxic chemical warfare agents.

- Exposure to minute quantities can kill quickly by attacking the nervous system.
- Stable, easily dispersed, and highly toxic.
- Rapid effect when absorbed through the skin or respiratory system.
- Liquids at ambient temperatures.
- Dispersed as an aerosolized liquid (vapor, not gas).

Be familiar with the following nerve agents;

- **Tabun (GA)** – Usually low **volatility, persistent chemical agent** that is absorbed through shin contact or inhaled as a vapor.
- **Sarin (GB)** – Usually volatile, **nonpersistent chemical agent** that is mainly inhaled.
- **Soman (GD)** – Usually moderately volatile chemical agent that can be inhaled or absorbed through skin contact.
- **Cyclohexyl sarin (GF)** – Low-volatility chemical agent that is absorbed through skin contact and inhaled as a vapor.
- **V-agent (VX) –** Low-volatility persistent chemical agent that can remain on material, equipment, and terrain for long periods, usually a skin absorbent.

G-series agents tend to be nonpersistent (vaporize and disperse quickly) unless manufactures thicken them with some other agent to increase their persistency.
Considering their low vapor pressure, nerve agents will not travel far under normal conditions. (See table 8.4 on Page 394).

Speed is the most important factor in medical management of individuals who have been exposed to nerve agents because of the rapid effects.
The immediate use of **autoinjectors** containing **antidotes** is the best treatment.

Nerve agent autoinjector

Blister Agents

Also know as Vesicants, blister agents burn and blister the skin.

They act on the eyes, mucous membranes, lungs, skin and blood-forming organs.

Blister agents are usually persistent and may be oily liquids ranging from colorless to pale yellow to dark brown.

May take several days or weeks to evaporate making decon difficult.

See table 8.5 on page 396 for more information.

Blister agents can be categorized into the following groups;

MUSTARD AGENTS
- Sulfur Mustards (H, HD, [also called distilled mustard], and HT).
- Nitrogen Mustards (HN, HN-1, HN-2, and HN-3).

ARSENICAL VESICANTS
- Lewisite (L, L-1, L-2, and L-3).
- Mustard/lewisite mixture (HL) mixture of lewisite (L) and distilled mustard (HD).
- Phenyldichloroarsine (PD).

HALOGENATED OXIMES – Phosgene oxime (CX).

Blood Agents

Chemical asphyxiants that interfere with the body's ability to use oxygen.

- **Arsine (SA)** – Gas formed when arsenic contacts an acid.
- **Hydrogen cyanide (AC)** – Colorless, highly volatile liquid.
- **Cyanogen chloride (CK)** – Colorless, highly volatile liquid.

See Tables 8.5, 8.6, and 8.7 on pages 396-398 for more info.

Choking Agents

Attack and cause tissue damage to the lungs, sometimes called *pulmonary* or *lung-damaging* agents.

Two of the most common choking agents are;

- **Chlorine** – Yellow-green colored gas usually stored pressurized and cooled to a liquid state for storage and transportation.
- **Phosgene** – Colorless nonflammable gas with an odor of freshly cut hay.

Riot Control Agents

Sometimes called *tear gas* or *irritating agents*.

In addition to tear gas, mace, pepper spray and other irritants, the following are categories of riot control agents;

- **Incapacitant** – Produces a temporary disabling condition that persists for hours to days.
  Examples are;
  - Central nervous system (CNS) depressants (anticholinergics).
  - CNS stimulants (lysergic acid diethylamide or LSD).
- **Vomiting agents** – An aerosol that causes violent uncontrolled sneezing, coughing nausea and vomiting.

See table 8.8 on page 400 for more info.

Toxic Industrial Materials (TIMs)

- **High Hazard:** a widely produced, stored, or transported TIM that is highly toxic and easily vaporized.
- **Medium Hazard:** a TIM that may rank high in some categories but lower in others, such as numbers producers, physical state, or toxicity.
- **Low Hazard:** this TIM is not likely to be a hazard unless specific operational factors indicate otherwise.

See table 8.9 on page 401 for a complete list.

Be familiar with SOPs/SOGs

The primary operational objective at a chemical attack is;

"do the greatest good for the greatest number"

Chemical attacks differ from other haz-mat incidents in the following ways;

- Severity of hazards present and need for appropriate PPE.
- Possibility of secondary devices.
- Mass Casualties.
- Need for rapid decon.
- Administration of antidotes.

Biological Agents

- **Viral Agents:** The simplest of microorganisms that can only replicate in their hosts and do not respond to **antibiotics**.
- **Bacterial Agents:** Microscopic single-celled organisms that usually do not cause disease in people.
- **Rickettsia:** Specialized bacteria that live and multiply in anthropoids (ticks and fleas) gastrointestinal tract, spread by the bite of the infected anthropoid.
- **Biological Toxins:** Poisons produced by living organisms. The organism itself is not harmful, the toxins are manufactured. (Anthrax)

An attack using a biological weapon may not be as immediately obvious as an attack using a bomb or industrial chemical.

Generally, biological weapon agents do not cause immediate health effects.

Most biological agents take hours, days, or weeks to make someone ill.

Because of this delay, the cause of illness may not be immediately evident and the source of the attack may be difficult to trace.

Biological Attack Indicators

Indicators include the following;

- Nonendemic illness for the geographical area.
- Casualty distribution aligned with wind direction.
- Electronic tracking of signs and symptoms reported to hospitals, pharmacies, and other health organizations.
- Illnesses associated with a common food, water, or location.
- Large number exhibiting flu-like symptoms during non flu months.

Disease Transmission

An infectious disease is caused by a microorganism and has the potential to transfer to another person, a contagious disease can spread rapidly from person to person.

Noncontagious diseases will only affect those individuals who have direct exposure to the disease agent itself, but an attack with a contagious agent such as smallpox or SARS has the potential to become an epidemic.

Operations at Biological Attack Incidents

To contain the spread of an agent, if possible keep exposed individuals from leaving the scene until a thorough risk assessment is made.

Isolation and containment issues will primarily involve managing infected victims, although public health officials will likely manage these issues.
Local plans for handling a **pandemic** flu may translate to other contagious disease outbreaks.

Radiological and Nuclear Attacks

There are many attack indicators, here are a few;

* Warning or threat of an attack or received intel.
* Individuals exhibiting signs and symptoms of exposure.
* Radiological packages left unattended in public locations.
* Suspicious packages that seem to weigh more than their appliance.

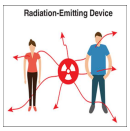
The entire list is on page 409.

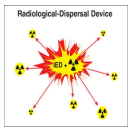
Radiological Devices

There are several designs that will expose people to radiation or dispersed radioactive materials.

Referred to as dirty bombs, the contamination they spread could ruin property, crops, and livestock.

These devices include **radiation-exposure devices (REDs), radiological-dispersal devices (RDDs), and radiological-dispersal weapons (RDWs).**





Operations at Radiological Attack Incidents

Responders should be cautious at suspected terrorist events, evaluate radiation levels, note areas of secondary devices, /enforce scene control zones.

The following geographical factors can complicate a radiological terrorism incident:

* Prevailing winds, broken water mains.
* Vehicle and/or pedestrian traffic flow.
* Ventilation systems.
* Air and rail corridors.

Tactics for radiological incidents include the following;

- Call for expert guidance, following AHJ SOPs.
- Preserve possible evidence for investigation.
- Do not conduct overhaul and cleanup operations; avoid disturbing the scene as much as possible.

The **ERG** provides guidance on general radiological incidents in Guide 163 regarding UN/DOT Class 7 materials.

Illicit Labs

Illicit labs may be used to manufacture drugs, explosives, biological weapons such as ricin, or chemical warfare weapons.

If you discover one, you should:

STOP, get out, and report it to authorities immediately.

Table 8.10 on page 413 provides key indicators of different illicit labs.

Courtesy of NASA

More info on illicit labs in Chapter 15.

The following are clues that may indicate an illicit lab;

- Laboratory glassware in unusual locations.
- Large quantities of household chemicals and pharmaceuticals.
- Hot plates.
- Unusual odors in unsuspected places such as hotel rooms.
- Unusual use of common items, coffee

Chemicals and equipment commonly found at meth labs.

Table 8.10 on page 413 provides key indicators of different illicit labs.

More info on illicit labs in Chapter 15.

Illegal Hazmat Dumps

These can occur in any jurisdiction where illegal disposers consider lawful disposal too expensive or complicated.

Illegal dumps pose the following significant problems and hazards;

- Unlabeled Containers.
- Mixed Chemicals.
- Aged Chemicals.
- Environmental Contamination.

Questions?

Hazardous Materials for First Responders

5th Edition

Chapter 9 - Implementing the Response:
Personal Protective Equipment

Respiratory Protection

Respiratory protection is a primary concern for first responders because inhalation is the most significant route of entry for hazardous materials.

Responders use the following types of protective breathing equipment at hazmat/WMD incidents:

- Self Contained Breathing Apparatus (SCBA).
- Supplied Air Respirators (SARs).
- Air-Purifying Respirators.
- Particulate Removing.
- Vapor and Gas Removing.
- Combination Particulate and Vapor and Gas Removing.
- **Powered Air Purifying Respirators (PAPRs).**

Standards for Respiratory Protection an Hazmat/WMD Incidents

The U.S Department of Homeland Security has adopted standards recommended by the National Institute for Occupational Safety and Health (OSHA) and the National Fire Protection (NFPA) for respiratory equipment.

NIOSH also certifies SCBA and recommends ways for responders to select and use protective clothing and respirators at biological incidents.

OSHA *29 CFR 1910.134* is the mandatory respirator standard in the U.S.

Self-Contained Breathing Apparatus (SCBA)

The most important piece of PPE a responder can wear at haz-mats.

The unit consists of;

* Facepiece.
* Compressed Air Cylinder
* End of service-Time Indicator.
* Pressure Regulator.
* Air Hoses.
* Harness Assembly.

In the U.S., NIOSH and the Mine Safety and Health Administration (MSHA) must certify all SCBA for **immediately dangerous to life and health (IDLH)** atmospheres. Do not use SCBA that is not NIOSH/MSHA Certified.

Advantages are;

* Independence.
* Maneuverability.
* Protection from toxins and/ or asphyxiating atmospheres.

Disadvantages are;

* Weight of the unit.
* Limited air supply.
* Change in profile may hinder mobility.
* Limited vision and communication.

Supplied Air Respirators (SAR)

The apparatus usually consist of the following;

* Facepiece
* Belt or facepiece mounted regulator
* Voice communication system
* Up to **300 feet** (90m) of supply hose
* Breathing air source (cylinder/compressor)
* Emergency escape pack or **emergency breathing support system (EBSS)**

Courtesy of MSA

The **EBSS** usually provides 5, 10, or 15 minutes of air allowing the user to escape a hazardous atmosphere.

SARs are not certified for firefighting because of the potential damage to the airline from heat, fire, or debris.

NIOSH classifies SARs as *Type C* respirators, divided into the following two approved types;

- Regulator and Facepiece.
- Regulator, Facepiece, and EBSS.

SARs have the following advantages and limitations;

Advantages:

* Reduces physical stress by removing the weight of the SCBA.

Limitations:

* Air line has potential for damage and is limited to 300 ft. (90m) that restricts mobility.
* Restricted vision and communications.

Air-Purifying Respirators (APRs)

Air-Purifying respirators (APRs) and Powered Air-Purifying Respirators (PAPRs) use specific purifying elements to filter air such as;

- Particulate-removing APRs.
- Vapor-and-gas removing APRs.
- Combination particulate-removing and vapor-and-gas removing APRs.

Courtesy of U.S. Marine Corp, photo by Cpl. Alissa Schuning

APRs do not supply oxygen or air from a separate source, and they protect only against specific contaminants at or below certain concentrations.

No single canister, filter, or cartridge protects against all chemical hazards.

The following questions must be asked before deciding to use APRs for protection at an incident;

* What is the hazard?
* What is the oxygen level?
* Is the hazard a vapor or a gas?
* Is the hazard a particle or dust?
* Is there some combination of dust and vapors present?
* What concentrations are present?
* Does the material have a taste or smell?

APRs can only be used if the material has a taste or smell.

APRs provide limited protection against oxygen deficient or oxygen enriched atmospheres and should not be used in IDLH atmospheres.

Three **primary limitations** of an APR are;

- Limited life of its canisters and filters.
- Need for constant monitoring of the atmosphere.
- Need for normal oxygen content of the atmosphere.

Take the following precautions before using APRs;

- Know what chemicals/air contaminants are in the air.
- Know how much of the chemicals/and contaminants are in the air.
- Ensure that the oxygen level is between ***19.5 and 23.5 percent***.
- Ensure that the atmospheric hazards are below IDLH conditions.

Particulate Removing Filters

High-efficiency particulate air (HEPA) filters used for medical emergencies must be 99.97 percent efficient, while 95 and 99 percent effective filters may be used depending on the health hazard.

Particle masks (also known as dust masks) are also classified as particulate removing air purifying filters.

These disposable masks protect from large size particles.

Provide very limited protection and should not be used to protect from chemical and small particle hazards

Vapor and Gas Removing Filters

These cartridges and canisters are designed to protect against specific vapors and gases by the use of a type of sorbent material to remove the targeted vapor of gas from the air.

Individual cartridges and canisters are usually designed to protect against related groups of chemicals such as organic vapors or acid gases.

Manufactures also provide info about contaminant concentration limitations.

Courtesy of MSA

Powered Air-Purifying Respirators (PAPR)

PAPR's can be used at hazmat/WMD incidents for Decon and long term operations.

WARNING: do not use PAPR's in explosive or potentially explosive atmospheres.

REMEMBER; at least 19.5 % oxygen and identification of the hazard is required for the use of any APR/PAPR.

Other Respiratory Equipment

Combination Respirators enables the user to switch modes of operation between a combination of SAR, APR, PAPR, and SCBA.

Supplied-Air Hoods are loose fitting, light weight, and can be used with glasses, facial hair, and beards.

Limitations of Respiratory Equipment

- Limited Visibility.
- Decreased ability to communicate.
- Increased weight.
- Decreased mobility.
- Inadequate oxygen levels.
- Chemical specification.
- Psychological stress.

CAUTION; Personal wearing respiratory equipment must have good physical conditioning, mental soundness, and emotional stability due to the physiological and psychological stresses of wearing PPE.

Protective Clothing Overview

Must be worn whenever responders face potential hazards from the following;

* Thermal Hazards.
* Chemical Hazards.
* Biological Hazards.
* Radiological Exposure.

Skin contact with hazardous materials can cause a variety of problems.

Protective clothing is designed to protect the wearer from potential exposure to hazards, ***most importantly the respiratory system.***

No single combination or ensemble of protective equipment (even with respiratory equipment), can protect against all hazards.

Fumes and chemical vapors can penetrate firefighting clothing. Chemical protective clothing (CPC) offers no protection from fires.

When used correctly, PPE provides protection for the following.

* Skin, eyes, face.
* Hearing, body, head and feet.

Body armor and bomb suits protect against ballistic hazards and shrapnel from explosives.

Standards for Protective Clothing and Equipment at Hazmat/WMD Incidents

NIOSH and NFPA: Standards for CPC use adapted by U.S. Department of Homeland Security (DHS).

ISO, the European Union, or other authorities: Depending on location, the standards regarding respiratory equipment may be issued by different agencies.

You should be familiar with any standards pertaining to design, certification, and testing requirements of any type of PPE, including body armor, structural firefighting gear, and bomb suits.

Structural Firefighter's Protective Clothing

Structural fire fighting clothing will provide limited protection against many hazardous materials.

Firefighter PPE does not provide complete protection against chemical hazards.

Some jurisdictions allow the use of structural firefighting protective clothing and SCBA to perform rescues.

Several limitations to high temperature clothing are as follows;

* Heat Stress.
* Bulky.
* Limits Vision.
* Limits Mobility.
* Limits Communication.
* Requires frequent/extensive training.
* Expensive.
* Designed for Limited Exposure Time.

Flame-Resistant Protective Clothing

Many responders wear **flame-resistant (FR)** work apparel during everyday activities.

Used where there is minimal risk for exposure to the following;

- Hot or molten materials.
- Hot surfaces.
- Radiant heat.
- Flash fires.
- Flame.
- Electrical arc discharge.

Flame resistant material can be achieved by using ***inherently flame-resistant fibers*** or by treating the material with a ***flame retardant chemical***.

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Chemical-Protective Clothing (CPC)

Chemical protective clothing (CPC) is designed to protect against specific chemical, physical, and biological hazards.

CPC material can contribute to heat disorders due to being designed moisture impermeable, which limits transfer of heat from the body through natural evaporation.

Users have considerations to make and duties to complete before and after wearing CPC.

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Liquid Splash Protective Clothing

Designed to protect user from chemical liquid splashes, but not against chemical vapors or gases.

This type of clothing can be **encapsulating** or non encapsulating, made of a single, one piece garment with boots and gloves or sometimes separate.

Limitations to <u>non-encapsulating</u> suits include;

* Protects against splashes and dusts, not against vapors and gases.
* Does not provide full body coverage, parts of the head and neck are sometimes exposed.
* Traps heat.

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Vapor Protective Clothing

Protects the wearer against chemical vapors or gases and offers a higher level of protection than liquid splash clothing.

Must be worn with positive pressure SCBA/SAR.

Vapor protective suits have the following limitations;

* May melt and burn if exposed to fire.
* Do not protect against all chemicals.
* Impairs mobility, vision, and communication.
* Does not allow body heat to escape, contributing to heat related injuries.

Mission-Specific Operations Requiring Use of Chemical Protective Clothing

- Site Surveys.
- Rescue.
- Spill Mitigation.
- Emergency Monitoring.
- Decontamination.
- Evacuation.

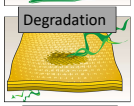
A written management program that includes policy statements, procedures, and guidelines, must be established if CPC is routinely used.

A CPC Management program includes the following elements;

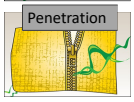
* Hazard Identification.
* Environmental Surveillance.
* Selection, Care, Testing, and Maintenance.
* Medical Monitoring.
* Training.

CPC's effectiveness can be reduced by the following three actions;

Breaches the suit at the molecular level.
Most manufactures provide breakthrough time charts with permeation rates.



Characteristics of a material are altered through contact with chemical substances.



When a material enters an opening or a puncture in a protective material.

Service life of CPC

Specific life the CPC is able to adequately protect the wearer.

Contaminated CPC must be removed from service.

WARNING: Never use CPC that is beyond its expiration date and/or has exceeded its service life.

PPE Ensembles, Classifications, and Selection

Adequate protection is achieved by an ensemble of respiratory equipment and clothing.

Consider the hazard and the actions that need to be performed when determining the appropriate PPE.

WARNING: No single type of PPE protects against all hazards.

CAUTION: Always follow your agencies SOP's/G's in determining the level of PPE necessary to perform a task.

Levels of Protection

There are different levels of protective equipment uses at incidents involving hazardous materials/WMD's:

Level A

Level B

Level C

Level D

Level A PPE

The highest level of skin, respiratory, and eye protection.

Protects against vapors, gases, mists, and particles.

Must be appropriately trained to wear Level A.

Used when risk analysist indicates it is appropriate; such as high potential for splash, immersion, or exposure to unexpected vapors, gases, or particulates that are harmful or capable of being a skin absorbent.

Level B PPE

Provides protection against splashes from a hazardous chemical.

Worn when the highest level of respiratory protection is necessary.

Provides little protection against fire.

May be encapsulated or non-encapsulated.

Used when the substance has been identified using detection or monitoring devices, oxygen level is outside normal ranges, or liquids or particulates are present.

Level C PPE

Level C is only used under the following conditions;

- The specific material is known and would affect exposed skin.
- The specific material has been measured and does not exceed IDLH levels and oxygen levels are **between 19.5 and 23.5.**
- The protection level has been approved by the IC and conditions for the use of APR's and PAPR's have been met.

Level D PPE

Typical work uniforms, street clothing, or coveralls.

Can be worn only when no atmospheric hazard exist.

Not worn in the hot zone and are not acceptable for hazmat emergency response above the Awareness Level.

Only used when work functions preclude splashes, immersion, or the potential for unexpected inhalation or contact with hazardous chemicals.

PPE Selection Factors

Many sources of guidance are available such as SOG's, allied professionals, hazmat technicians, the emergency response plan, and the site safety plan.

Selection of PPE and equipment must afford the adequate level of protection, overprotection as well as under protection must be avoided.

Consider the following general selection factors;

* Chemical and physical hazards.
* Monitoring and detection readings.
* Exposure duration.
* Physical environment.
* Available PPE or equipment.
* Compliance with regulations.

Typical Ensembles of Response Personnel

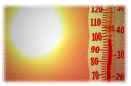
The ensemble worn at an incident will vary depending on the mission of the responder.

Fire Service Ensembles

Law Enforcement Ensembles

EMS Ensembles

PPE Related Stresses



Heat Emergencies

* Heat Stroke (the most serious).
* Heat Cramps.
* Heat Exhaustion.
* Heat Rashes.

Heat Exposure Prevention

- Fluid Consumption.
- Air Cooling.
- Ice Cooling
- Water Cooling.
- Cooling Vests.
- Rest/rehab Areas.
- Work Rotation.
- Proper Liquids and physical Fitness.

Water and air cooling becomes less effective as air humidity increases and water temperatures rise.

Cold Emergencies

Caused by weather and/or other conditions such as exposure to cryogenic liquids.

Prolonged exposure to freezing temperatures can result in health problems as serious as **trench foot**, **frostbite**, and **hypothermia**.

Low temperatures, high/cool winds, dampness, cold water, and standing/walking/working on cold, snowy, and or/icy surfaces are all environmental conditions that cause cold related stresses.

Wind Chill, a combination of temperature and velocity, is a crucial factor to evaluating when working outside. (see table 9.5, page 459)

Cold disorders can be prevented with the following precautions;

- Being active and Rehabbing in a warm area.
- Wearing warm clothing/layers.
- Dressing appropriately and Avoiding cold beverages.

Psychological Issues

The use of CPC can be a confining experience, much more than wearing firefighter clothing, which can cause claustrophobia in responders.

Psychological issues may be prevented through adequate training, gaining familiarity and confidence.

Emergency response in CPC may not be suitable for all responders.

Medical Monitoring

Medical monitoring should be conducted on all responders wearing CPC prior to entering the warm and hot zone as well as after exiting these zones.

Check things as vital signs, hydration, skin, mental status, and medical history.

Exposure records should include the following;

* Type and length of exposure.
* Description of PPE used.
* Type of DECON used, (include solutions).
* On scene and follow up medicals.

PPE Use

Learning how to safely use PPE will increase the responders comfort and proficiency.

A pre-entry inspection is the first step in PPE use consisting of a visual inspection, test completion dates, and operational check.

An operational check includes;

- Breathing apparatus.
- Zippers, closures, and valve.
- Communication Equipment.
- Any other equipment to be used.

Safety and Emergency Procedures

Use the “Buddy System” anytime entering an IDLH atmosphere.

Minimum of two members with the same level of training in backup.

Operate within your accountability system and know your evacuation and escape procedures.

Participate in a safety briefing prior to hot zone entry.

Relevant info covered in a safety briefing includes the following;

* Incident status.
* Identified hazards.
* Description of the site.
* Tasks to be performed.
* Expected duration of the tasks.
* Escape route/area of refuge.
* PPE/health monitoring requirements.
* Incident monitoring requirements.
* Notification of identified risks.
* Communication procedures.

Air Management

Air management is an important consideration anytime a limited air supply, such as SCBA, is worn.

To ensure adequate work time, calculate estimated times for the following tasks;

- Walk to the incident.
- Return from the incident.
- Decon.
- Work time.
- Safety time, (extra for emergency use).

Contamination Avoidance

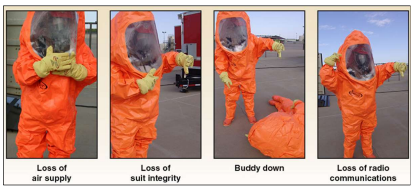
Consider the following best practices to avoid contamination;

* Avoid walking through and touching the product.
* Do not kneel or sit on the ground in CPC.
* Protect monitoring instruments.

NOTE: If avoidance is not possible and you need to protect the suit, put something like thick cardboard, rug, absorbent pillows, between your suit and the ground/contamination.

Communications

Some level of communication is required for all levels of personal protection which may be integrated into PPE or be of predesignated hand signals, motions, and gestures.



Donning and Doffing of PPE

The donning process can be quite time consuming and confusing if the wearer is not totally familiar with the garments.

You should always train with the protective clothing that you will be using in the field.

Manufacture and department recommendations for donning PPE must be followed.

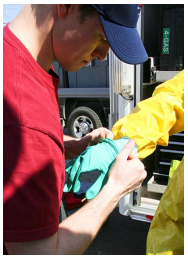
Donning and Doffing of PPE

Know the generic PPE donning procedures;

* Conduct mission briefing.
* Deploy chemical protective clothing in an organized manner.
* Check all equipment visually and operationally.
* Ensure removal of personal effects.
* Don appropriate undergarments.
* Preselect clearly delineated area in cold zone close to entry point.
* Ensure area is isolated from distractions and sheltered from the elements.
* Select large enough area to accommodate all personnel.
* Entry, backup members medically evaluated per AHJ procedures.
* Continue hydration per AHJ procedures.

Backless chairs or benches will accommodate SCBA's.

Assistants will be needed to help don CPC.



Doffing of PPE

Upon exiting the hot zone, entry personal are decontaminated prior to doffing of the PPE.

Entry members are assisted to by doffing personnel who may wear a lower level of PPE..

Entry personnel will be hot, tired, and anxious to remove the clothing.

The generic procedure for doffing PPE is as follows;

* Personnel wearing PPE should allow assisting personnel to do the work.
* To avoid cross contamination, entry members only touch the inside of PPE, assisting members only touch the outside.
* Once PPE is removed, zip or store so that inside and outside surfaces can not touch.
* All entry PPE placed in a marked container.
* The last item removed is the respirator facepiece.
* Breathing apparatus should be isolated and marked for Decon.
* All entry and support members must report to rehab.

Inspection, Storage, Testing, Maintenance, and Documentation

Follow a standard program of inspecting and maintaining PPE.

Inspect PPE: On initial receipt, before and after each use, periodically as recommended by the manufacturer.

Inspect respiratory equipment: Each use, daily or weekly, monthly, annually per manufacturers recommendations.

Store CPC and other PPE so that it will not be damaged by sunlight or other potentially harmful exposures.

Questions?