

# **JAMAICA FIRE BRIGADE**

TRAINING DEPARTMENT



## **HAZARDOUS MATERIALS**

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## Introduction

The term hazardous materials covers a broad range of substances with a wide variety of effects. Some materials are highly toxic to humans. Others are dangerous primarily because they are flammable, though many can cause health effects as well. Exposure to various hazardous material may have **immediate effects, delayed effects or no detectable effects at all**

Hazardous Materials are any substances that will jump out of its container at you when something goes wrong and harm the thing it touches or impinges upon. Your response as a First Responder to hazardous materials incidents must include the following duties:

- Analyze the problem
- Plan the response with the safety of responders as a primary concern
- Implement the planned response
- Evaluate the progress, adjusting the plan as needed
- Hazardous materials may be present at non-structural alarms, transportation incidents and residential and commercial occupancies
- Hazardous materials may include chemicals, infectious agents, and radioactive hazards
- Chemicals may have more than one hazard associated with them, for example, a flammable liquid may also be toxic
- To respond effectively to a hazard materials incident, you must realize the incident, plan your response, implement your actions and evaluate their effects

## HEALTH AND SAFETY

### i. HAZARDS, EXPOSURE AND CONTAMINATION

Your positive-pressure self-contained breathing apparatus prevents your exposure but remember that your equipment cannot always adequately protect you from the hazards. Many gases and vapors can easily penetrate turnout clothing.

It is also important to distinguish between **exposure** and **contamination**. An individual is **exposed** when a chemical, infectious materials, radioactive substance, or other agent enters or is in direct contact with the body.

**Contamination** occurs when the hazardous substance remains on the clothing,

hair, skin, or other part of that individual. However, exposure can occur without contamination, especially when certain gases or specific forms of radiation are involved. For example, carbon monoxide does not cling to turnout clothing, so contamination will not occur. Contamination usually results in exposure, unless only the outside of protective clothing is contaminated.

## ii. ROUTES OF EXPOSURE

There are three routes through which hazardous materials can enter the body:

**absorption** through the skin, **inhalation** through the lungs or **ingestion** through the mouth.

### a. Absorption

The skin provides a barrier that varies in its protective effectiveness depending on its condition, the site of contact and the properties of the hazardous materials. Absorption of materials through the skin is **time dependent** – the longer the contact, the greater the amount of chemical absorbed. The rate of absorption is also influenced by **skin temperature and blood supply** at the entry site. Areas rich in hair follicles, such as the scalp, forehead, jaw area and underarm, allow much greater absorption than do other parts of the body. Furthermore, higher concentrations of materials in contact with the skin tend to result in greater amounts absorbed. Usually, the more chemical absorbed, the more severe the health effects.

Intact skin is normally a good barrier to foreign substances. Damaged skin is more susceptible to further damage from hazardous materials and may allow increased absorption of chemicals into the body.

### b. Inhalation

The lungs act as a “transfer point” in the human body. Oxygen and other substance pass from the atmosphere to the bloodstream, and carbon dioxide passes from the blood stream to the atmosphere.

Many chemicals are absorbed through the lungs after they have been inhaled. However, the lungs do have some protective features. The mucous cells within the lining of the nose trap inhaled particles.

Like the skin, the lungs may serve only as a route of entry and may not be affected by the inhaled hazardous material. For example, carbon monoxide easily enters the blood stream when inhaled. There, it binds with the oxygen-

carrying part of the blood cell, preventing oxygen from entering the body's tissues.

c. Ingestion

Although hazardous materials exposure through ingestion is common in cases of suicide and childhood poisoning, it is less common in work and environmental exposures. However, ingestion can occur when hazardous substance comes in direct contact with the mouth or when contaminated hands or clothing come into contact with the mouth. In addition, it is possible to consume toxic materials by eating or smoking in an environment where food and cigarettes can become contaminated.

The gastrointestinal system includes the mouth, pharynx, esophagus, stomach, small intestine and the large intestine.

In all cases of exposure, it is important that you document the *amount* of exposure. This includes noting the concentration of the chemical in air (if inhaled), the volume (if swallowed), or the amount of body surface area affected. The duration of the exposure must also be noted, since the longer the material is in contact with the body tissues, the greater the amount absorbed.

**iii. TYPES OF TOXIC EFFECTS**

Various chemicals have different effects on the body. Some effects are more likely to result from short-term, high level exposures. Other effects are more likely to result from the long-term exposure. Also, remember that a single chemical may produce a range of effects.

a. Asphyxiants

Asphyxiants are gases that deprive the body tissue of oxygen. There are two types of asphyxiants: simple asphyxiants and chemical asphyxiants.

Simple asphyxiants displace oxygen.

Chemical asphyxiants are gases that prevent oxygen *use* by the body's tissues, even though enough oxygen is inhaled. Carbon monoxide and hydrogen cyanide are chemical asphyxiants.

b. Corrosives

Corrosives can cause irreversible tissue damage. This tissue damage, if mild, may resemble a burn from heat. Acids and alkalis (bases) are corrosives. Their effects depend on the concentration of the chemical and the strength of the acid or base

c. Irritants

Irritants causes temporary but sometimes severe inflammation of the eyes, skin, or respiratory tract. Irritation may result in permanent damage if it is repeated over time. The symptoms of irritation depend on the tissue affected. Some symptoms of irritants are coughing, difficulty in breathing, itching and redness of skin and eyes.

d. Sensitizers

Sensitizers can cause allergic reactions after repeated exposure. The reaction may appear several hours after exposure to the sensitizing chemical. Repeated exposure cause a rash on skin or an asthma like reaction if the sensitizer is inhaled

e. Carcinogens

Substances that cause cancer are called carcinogens. Carcinogens may affect an organ or organs that are quite distant from the route of entry. Examples of carcinogens include benzene, which is associated with leukemia, vinyl chloride, which is associated with specific type of liver cancer, and asbestos, which causes a specific type of lung cancer and increases the risk of all lung cancers among exposed individuals.

f. Neurotoxic Chemicals

Neurotoxic chemicals cause damage – either permanent or reversible to the central nervous system (the brain and the spinal cord) or the peripheral nervous system (the nerves responsible for movement and sensation in the arms, hands, legs, and feet).

g. Other Toxic Effects

Hazardous materials exposure may also target the liver, the urinary system or the reproductive system. Effects on these organs can be overlooked because symptoms of exposure are not obvious. This is another reason that documenting exposures is important, even if you do not feel ill following exposure.

h. Special Hazardous Materials

1. Radioactive Hazards

Radioactive materials may emit alpha or beta particles or gamma rays. These agents can affect the cells of the body in various ways, but each is capable of destroying cells.

In an emergency situation, you may know only that a material is radioactive without which type of radiation is being emitted. You can minimize your experience to any type of radiation by limiting the **time** that you are near the source of radiation; increasing the **distance** between yourself and the source; and **shielding** yourself with appropriate material. SCBA and bunker gear can shield you from most alpha and beta radiation; several inches of lead is necessary to shield you from gamma radiation.

Like other exposures, if your clothing or skin is contaminated with a radioactive substance, exposure will continue until you are decontaminated.

2. Infectious (Etiologic) Agents

Like chemicals, biological agents can gain access to the human body primarily through inhalation, ingestion and contact with skin. Biological agents can also enter the blood stream directly through breaks in the skin.

Infectious agents include **viruses** such as hepatitis A, hepatitis B, hepatitis C, human immunodeficiency virus (HIV) and the herpes virus. In emergency response, the virus that causes hepatitis and AIDS are most easily transmitted through exposure to blood and other body fluids. Avoid exposures to blood and any other body fluids including urine, feces vomits and any body tissues.

## RECOGNITION AND IDENTIFICATION

The ability to recognize and identify the presence of hazardous materials is essential to First Responders. It is only after a material is identified, or at least classified that its characteristics and hazards can be determined and the appropriate response taken

### I. IDENTIFYING CLUES

When responding to a call, review the information provided by the caller or dispatcher for indications that hazardous materials are involved (such as a suspicious odor, an individual collapse suddenly in a confined space, an odd colour of smoke.

#### a. Occupancy and Location

The occupancy and location of a site can provide valuable clues. If the processes, materials used, and products manufactured at a particular site are known, First Responders can begin to make some determinations about the hazards that are likely to be involved.

Pre-incident planning and inspections help determine where hazardous materials are stored, used and transported in a community and what emergency plans, if any, have been developed by the owners.

#### b. Placards, Labels and Marketing

Placards, labels and markings provide information about the type and hazards of products being transported or stored. There are a number of marking systems required or strongly recommended where hazardous materials are present.

The DOT System: Placards and Labels

It is essential that you be familiar the DOT (Department of Transportation) system because placards and labels may provide the initial and most valuable clue regarding the type of hazardous materials that is being carried.

**DOT placards** are diamond-shaped signs (10 -  $\frac{3}{4}$  inches on each side) that generally must be affixed on each side and each end of vehicles carrying hazardous materials.

## Hazard Class Numbers

The UN (United Nations) hazard class number must appear in the bottom of the diamond on both placards and labels.

All of the above information is contained in the recommended North American Emergency Response Guidebook. This book provides the user with information such as how to use the book, set out basic guideline of what to do in emergencies, how to identify the material being transported or stored, table of isolation and protective action distance.

The yellow pages give information as to the name of the material, the blue pages give information as to the chemical name and the UN identification number, the orange pages gives information as to the potential hazards and emergency response and the green pages provide information in respect to isolation and protective action distance.

### a. Container Shape and Design

The shape and design of containers used in transportation and storage may indicate when hazardous materials are present. Shape and design may also indicate the general type of materials in the container, for, example, whether or not it is kept under pressure. Container and vessel shapes are often specific for certain materials being shipped or stored and many are regulated by law.

### b. Shipping Papers and Facility Documents

All shipments of hazardous materials as defined by DOT, must be accompanied by shipping papers. The type of shipping paper varies depending on the mode of transportation. The chart below lists the type of shipping paper that corresponds to each mode of transportation.

**Shipping Paper Responsibilities by Mode of Transportation**

<b>Mode of Transportation</b>	<b>Title of Shipping Paper</b>	<b>Location of Shipping Papers</b>	<b>Responsible Person</b>
Highway	Bill of Lading or Freight Bill	Cab of vehicle	Driver
Rail	Waybill and/or Consist	With member of train crew (conductor or engineer)	Conductor
Water	Dangerous Cargo Manifest	Wheelhouse or pipe-like container on barge	Captain or Marker
Air	Air Bill with Shipper's Certification for Restricted Articles	Cockpit (May also be found attached to the outside of packages)	Pilot

These papers provided detailed information about the contents of the shipment. Shipping papers may alert you to the presence of hazardous materials through a variety of required entries

## II. INFORMATION SOURCES

After clues have been detected and the presence of a hazardous material has been recognized, First Responders can draw on a number of resources to identify the specific material and hazards involved. Identification of the hazard will help you decide the appropriate course of action.

The resources available to you will depend on your **jurisdiction, equipment training and standard operating procedures**. These resources commonly used to provide additional information about hazardous materials include reference books, telephone hotlines, detection devices and to a very limited extent, your senses.

### a. Reference Books

There are several reference books available to assist in identifying hazardous materials. Two commonly used references are the DOT Emergency Response Guidebook and NIOSH Pocket Guide to Hazardous Materials.

The DOT Emergency Response Guidebook has numerous advantages as well as certain disadvantages that you should be aware of:

Advantages:

- Instructions for using the guidebook are included
- Placards are illustrated
- Phone numbers to call for assistance are included
- Chemicals are listed alphabetically by name
- UN numbers are listed in numerical order
- Key words and terms are defined
- Initial evacuation distances are provided

Disadvantages:

- Information is very general
- Evacuation table is good for only 30 minutes
- Recommended actions may be inappropriate in some cases

b. Telephone Hotlines

Telephone hotlines can provide general information about hazards and possibly, responder actions.

c. Detection Devices

Instruments and meters can detect the presence of hazardous materials in the atmosphere and measure their concentrations. **However, these devices can be expensive, require formal training and are often not available** to First Responders. In addition, use of these instruments may put First Responders at risk for exposure to the materials being measured.

d. Your Senses

For the most part however, using your senses (other than vision) to detect a hazardous material is unsafe and unacceptable. For instance, if you hear a gas or vapor escaping from a container, you may have found the source of a release, **but you are dangerously close to it.** Though you should note anything unusual that you can see, hear, smell or experience, you should also avoid further exposure. For example, after exiting a structure involved in fire and removing your breathing apparatus mask, you may notice eye or skin irritation. This should alert you to the possibility that there is an irritating or corrosive agent in the atmosphere and operations should be modified appropriately.

With vision aided by the use of binoculars, you can detect a release of such as vapor cloud, spilled liquid, or smoke from a fire. The presence of any dead animals or fish nearby should alert you to the possibility of hazardous material contamination in the area.

## **BASIC PRINCIPLES OF CHEMISTRY**

First Responders must be familiar with some of the fundamental principles of chemistry in order to understand and predict chemical reactions at hazardous materials incidents. This understanding can help you plan response actions, anticipate the effects of the other factors such as impinging flames or water application and judge whether you can be adequately protected from the materials.

## I. GENERAL PRINCIPLES

### a. States of Matter

All elements exist in nature in one of three states: **solid, liquid or gas.** Substance can change from one state to another as changes occur in temperature or pressure, or both. A change in a material's state is likely to affect the degree of hazard posed by the material, as well as the tactics appropriate for controlling the hazard. For example, a toxic substance may be more hazardous in the gaseous state than in the liquid state because it is easier to inhale when it is in the gaseous state.

#### Solids

A solid is a substance that retains a definite size and shape under normal conditions. When most solids melt, they change to liquid. The temperature at which this occurs is called **melting point**. When solids change directly to gas, the process is called **sublimation**.

#### Liquids

Liquids are substances that flow easily and have a specific volume but no specific shape. The temperature at which a liquid freezes is called the **freezing point**. At this temperature which is unique to liquid, bubbles of the liquid rise to the surface and enter the surrounding air. The boiling point of a liquid is related to its **vapor pressure**.

**Vapor Pressure** is a measure of the ability to evaporate, that is, to change from a liquid to a gas. The higher the vapor pressure, the more likely a liquid is to evaporate.

And as temperature increases, the vapor pressure of a liquid increases. If the temperature is high enough, the vapor pressure rises until it equals atmospheric pressure. At this point, the liquid boils and become vapor. Because liquids expand when they vaporize, the effect of temperature on a liquid's pressure can be catastrophic if the liquid is in a closed vessel. If there is no mechanism for venting, the vapors generated as the liquid is heated will exert increasing amounts of pressure on the vessel, possibly leading to container failure.

Flammable liquids with high vapor pressure are generally more dangerous than those low vapor pressures. This is because they more readily form ignitable mixtures in air and are more easily inhaled. **Flash point** is the **temperature** at which a liquid generates enough vapors to create an ignitable mixture near the surface of the liquid. **Explosive (flammable) limit** refers to the **concentration** of a flammable vapor or gas in air. Below the lower explosive limit (LEL), the mixture is "too lean" to ignite. This means that there are not enough flammable vapors in the air. Above the upper explosive limit (UEL), the mixture is "too rich" to ignite. That is, there is too little oxygen to support combustion. Between the LEL and UEL, the mixture is explosive or flammable.

## Gases

A gas is a substance that expands or is compressed readily and has no independent shape or volume. Gases may condense to form liquids; this change occurs when a gas is cooled to or below its boiling point. (Substance that occur naturally as gases have low boiling point compared to solids and liquids).

To evaluate the hazard posed by a gas, you must know (or estimate) its concentration in the air. Explosive limits, discussed above, are one way to evaluate the concentration of flammable gases and vapors.

### b. Specific Gravity

Specific gravity is a concept used to measure the weight of solids and liquids *in comparison to an equal volume of water*. Water has a specific gravity of one. Solids and liquids that are heavier than an equal volume of water have specific gravities greater than one. Similarly, solids and liquids that are lighter than water have specific gravities less than one.

**Specific gravity has no unit of measure. It is only a relative value (relative to water). The specific gravity of a substance indicates it will sink or float in water.**

c. Solubility

**Solubility refers to the degree that one substance mixes with another substance.** The mixture is called **solution**. The substance present in greater amount is called the **solvent**. Water can be a solvent, though in common usage the term refers to petroleum-based chemicals. The substance present in lesser amount is called the **solute**. A solute may be a gas, a liquid or a solid.

If a solute mixes completely in a solvent, it is said to be **miscible** with that solvent. For example, alcohols such as methyl, ethyl, and propyl alcohol are miscible in water. **Water miscible** means that the liquid is infinitely soluble in water.

d. Vapor Density

Vapor density is a similar concept used to measure the weight of gases in comparison to an equal volume of air. Air has a vapor density of one. Substances with vapor densities less than one are lighter than an equal volume of air and will rise in air. Those with vapor densities greater than one will sink in air and often collect in low-lying areas or close to the ground. This is important when sampling the air, identifying safe areas during an emergency and predicting how a gas will spread

e. Chemical Reactivity

Chemical reactions result when two or more substances combine to form new chemicals and energy is either absorbed or released. Polymerization, combustion and ionization are examples of chemical reactions. The rate at which a chemical reaction occurs depends on a number of factors including:

- **Temperature** – increasing temperature usually speeds reactions

- **Concentration** – increasing the concentrations of the reacting materials usually increases the rate of reaction
- **Pressure** - increasing pressure, especially on reacting gases and vapors, may speed reactions, though this is not always true
- **Catalysts present** – a catalyst is a substance that increases the rate of chemical reactions, but is not changed by the reaction

In addition to the factors listed above, the physical and chemical properties of the reactive materials can influence the reaction. For example, gases and vapors react more readily than liquids and solids. And highly reactive materials can spontaneously explode or ignite when exposed to another substance.

**Water-reactive** materials are those that react when exposed to water. For example, sodium metal is extremely water-reactive and may explode when in contact with water. |

**Air-reactive** materials are those that react when exposed to air. White and yellow phosphorous spontaneously ignite in air.

#### f. Temperature

Temperature plays a very important role in both fire fighting and response to hazardous materials incidents because it can affect the nature of a chemical reaction. Three different scales are used to measure temperature: Centigrade, Fahrenheit and Kelvin. The first two scales are in common use and appear in reference textbooks and chemical databases. The Kelvin scale is used primarily in technical and scientific settings.

**Centigrade (C)** (sometimes called Celsius) is the scale on which water boils at 100° and freezes at 0°. To convert °C to °F, use this formula:

$$^{\circ}\text{F} = (^{\circ}\text{C} \times 9/5) + 32$$

**Fahrenheit (F)** is the scale on which water boils at 212° and freezes at 32°. To convert °F to °C:

$$^{\circ}\text{C} = (^{\circ}\text{F} - 32) \times 5/9$$

For example:  $(212^{\circ}\text{F} - 32) \times 5/9 = 180 \times 5/9 = 100^{\circ}\text{C}$ .

g.  $p^H$

The  $p^H$  scale is a reference scale indicating the acidity or alkalinity of materials. The scale ranges from 0 to 14, with 7 considered neutral. Values lower than 7 indicate increasing acidity, while those higher than 7 indicate increasing alkalinity. The  $p^H$  scale is a logarithmic scale with 7 at the center of the scale.

When dealing with acids and bases, it is also important to obtain information about the **concentration** of the acid or base. Concentration indicates the **percentage** of the material in water.

Both acids and alkalis can cause injury. Materials with either a very low or very high  $p^H$  are the most hazardous and any highly concentrated acids or bases should be carefully assessed before action is taken.

## II. RADIATION

Though radiation is a **physical** property, not a chemical property, it still represents a potential hazard to First Responders. Radioactivity involves the property of certain elements to **emit energy** that can damage living organisms. This energy is typically in the form of alpha particles, beta particles or gamma rays.

Alpha particles can travel only a short distance from their source (up to about 4 inches) and can be stopped by a thin film of water or a sheet of paper, Beta particles can travel further than alpha particles, about 30 feet from their source. They can penetrate about 1½ inch of wood and through 1/10 to ½ inch of human skin. Alpha and beta particles cause the most harm if they are inhaled or ingested. Beta particles can also cause serious skin burns and are particularly hazardous to the eyes.

Gamma rays carry higher energy and are more penetrating than alpha or beta particles. These rays are only stopped with dense shielding, such as several inches of lead or several feet of concrete. Gamma rays can easily penetrate through the skin. The amount of radiation absorbed by an exposed individual depends on several factors including the length of exposure (**time**), the **distance** from the source and the presence of any **shielding** between the person and the source. Any of these factors – **time, distance or shielding** – can be used to minimize exposure. **Distance is the most effective means of reducing exposure. By doubling the distance from the source, an individual can quarter the amount of radiation exposure.**

### III. POINTS TO REMEMBER

- A solid becomes a liquid at its melting point; a liquid becomes a vapor at its boiling point.
- The higher a chemical's vapor pressure, the more easily it can change from a liquid to a gas; any chemical with a vapor pressure above 760 mm Hg is likely to be in the gaseous state at room temperature.
- Lower and upper explosives limits (LEL and UEL) refer to the minimum and maximum concentrations of a flammable gas or vapor that can be ignited
- Liquids and solids with specific gravities greater than 1 will sink in water; those with specific gravities less than 1 will float in water.
- Vapors and gases with vapor densities greater than 1 will sink in air, those with vapor densities less than 1 will rise in air
- A chemical with a  $p^H$  less than 7 is acidic; a chemical with a  $p^H$  greater than 7 is alkaline
- The principles of time, distance and shielding can be used to minimize exposure to radiation.

### EVALUATING DAMAGE TO CONTAINERS AND ESTIMATING OUTCOMES

After you have detected the presence of hazardous materials, you must use the clues to identify the material involved. After you have identified the material, you can refer to various written resources, telephone hotlines or experts to determine the physical and chemical properties and the possible toxic effects of the material. With this information and an understanding of the container for the hazardous material, you should be able to predict how the material and its container will react and the likely effects of a release. If information is incomplete, you should take action based on the "worst case scenario", for example, container failure.

## I. EVALUATE DAMAGE TO THE CONTAINER

You should assess the container as thoroughly as possible from a location uphill and upwind of the material and container.

### a. Identify Damaged Containers

If you know what the container normally looks like, you should be able to identify obvious abnormalities or deformities in the container shape. The position of the container may be different from normal. You should also observe if there are any other damaged objects in the area.

### b. Determine Construction of the Damaged Container

If you can identify the type of container using recognition and identification skills, you may be able to determine what the container is made of. For example, you should know that non-pressure cargo tanks are typically made of aluminum. This material is lightweight and will melt rather than explode in the event of a fire involving flammable liquid cargo.

### c. Determine Type and Location of Container Closures

Closures include valves, ports and other openings. These may be particularly susceptible to damages.

### d. Determine Type and Location of Damage

Damage may occur to the container or its closures. If possible, should assess the specific type of damage including:

- **Cracks:** splits or breaks that may or may not penetrate through the construction material
- **Dents:** depressions in the surface of a container caused by contact with another object
- **Gouges:** removal of the container's construction material by another object along the line of contact
- **Scores:** similar to gouges, except that the container material is only pushed aside, not removed

- **Metal reduction:** caused by either abrasive or corrosive action on the container
- **Punctures:** holes in the container made by a sharp object
- **Tear** a separation of the container or its closures as a result of being pulled apart

c. Predict How the Contents will be Released

There are several types of releases including the following:

- **Detonation:** a complete disintegration of the container and/or explosion of the contents which occurs in less than 1/100<sup>th</sup> of a second
- **Violent rupture** failure resulting from runaway linear cracking of the container and the rapid expansion of the contents; occurs in less than 1 second
- **Rapid relief:** a pressurized flow of the contents through valves or through a breach in the container; occurs over minutes to hours
- **Spill or leak:** a gradual flow of product through attachments or through a breach in the container; occurs over minutes to hours

The First Responder must also be able to predict how the container will breach, dispersion pattern, the duration of hazardous condition and the harm that the hazard will cause.

## SCENE MANAGEMENT

### I. INCIDENT MANAGEMENT SYSTEMS

Emergency incidents can be resolved successfully when the health and safety of responders is maintained as the highest priority, when tactical objectives are appropriate for the established goals and when the scene is managed in a systematic manner.

Effective scene management depends on a well-defined structure that is outlined in standard operating procedures, routinely practiced, and used at *all* incidents. An operation without an incident management system leads to poor utilization of resources and endangers the health and safety of response personnel.

**Isolate hazard area and deny entry** means to keep every away from the area if they are directly involved in the emergency response operation.

**Evacuate** means to move all people from a threatened area to a safe place

**In place protection** means to direct people to quickly go inside a building and remain inside until the danger passes.

## II COMMAND FUNCTIONS

There are a number of basic objectives that must be met by the first units and the command officer upon arriving at the scene of a hazardous materials incident.

- Establish command and secure the area
- Survey the incident scene
- Collect and interpret information on each material's hazards and appropriate response
- Evaluate the extent of damage to each hazardous material container and predict its likely behavior
- Assess vulnerable populations within the affected area and initiate protective actions as appropriate
- Isolate the hazard using defensive actions
- Continuously evaluate the situation and change actions as necessary

### a. Establish Command and Secure The Area

First Responders must secure the scene and control access to the area as early as possible during the incident. The establishment of controlled access area should start at an outside perimeter and work toward isolation of the contaminated area. **The Warm and Hot Zones should be established after the outer perimeter is secured.**

### b. Survey the Incident Scene

The process of surveying or sizing up hazardous materials incidents is the same used for other fire department responses. Regardless of the hazard, the

strategic priorities are the same: **life safety** (operating forces and civilians), **incident stabilization, and property and environment conservation**. When conducting a size-up, position yourself **uphill and upwind** of any release and consider terrain and weather conditions.

c. Collect and Interpret Information on Hazards and Response Actions

With aided vision, the Incident Commander must determine what, if any containers are in use. Examples of containers include:

- **Non-Bulk Containers** bags, bottles, boxes, carboys, cylinders, drums, jerricans, multicell packages, wooden barrels
- **Bulk Containers** bulk bags, bulk bottles, cargo tanks, covered hopper cars, freight containers, gondolas, pneumatic hopper trailers, portable tanks and bins, protective overpacks for radioactive materials, tank cars, ton containers, van trailers
- **Facility Containers** buildings, piping, reactors (chemical and nuclear), storage bins, tanks and storage vessels

Using recognition and identification skills, responders must evaluate container markings and estimates the amount of hazardous materials present.

Conditions surrounding the incident must also be considered when evaluating an incident. All responders should monitor the scene continuously for possible ignition sources, such as pilot lights, sparks from internal combustion engines, and sparking from non-intrinsically safe equipment.

d. Evaluate Damage To Containers and Predict the Likely Behavior of The System

In determining what is likely to happen to hazardous material and its container, the Incident Commander must note the types of stress or potential stress on the system. **Stress** is the force on the container that is capable of straining or deforming the container. Stress may also be caused by **thermal** (temperature) and factors, **mechanical** stressors such as the stress of an impact or **chemical** stress such as corrosion caused by the contents.

The stresses are likely to weaken container making container **breach** or failure more likely. If the container fails, a release, spill, or other loss of product may occur.

e. Assess Vulnerable Populations and Initiate Necessary Protection Actions

One of the most important task for the Incident Commander to evaluate is the need for rescue and protective actions for groups of people, **Rescue of endangered individuals at hazardous material incidents should not be performed unless the safety of the rescuers can be assured.** Initial actions should be devoted to removing able-bodied persons, the “walking wounded” from immediate danger. Complicated rescues or difficult extrication should be evaluated thoroughly before being attempted.

- When actions are directed toward **property conservation only**, firefighters should be subject only to **low risk** environments. Risk nothing for people and property that has already been lost.
- When actions are directed toward the rescue of **trapped victims who have low probability of survival**, firefighters may be subjected to **moderate risk** environments.
- When actions are directed toward the rescue of **trapped victims who have a high probability of survival**, firefighters may be subjected to **high-risk** environments. It is reasonable for firefighters to face risk in order to save lives.

When contaminated individuals are rescued, the Incident Commander must arrange the isolation, decontamination and treatment of these patients and rescuers who were contaminated in the process.

f. Isolate the Hazard

First Responder actions for isolating the hazards are limited to **defensive** tactics only. While response recommendations found in the references and advise from experts should influence the Incident Commander’s decision regarding tactics, he/she must also weight the risks and benefits of specific actions.

**Before any actions are taken, there must be a sufficient number of personnel on the scene.**

g. Evaluating and Revising Actions

Throughout the incident, those with supervisory responsibilities must determine whether objectives are being met. The following areas should be considered:

- Does the strategy ensure the safety of personnel?
- Are personnel being tracked throughout the incident scene?

- Are strategic priorities being met?
- Are crews operating according to standard procedures?
- Are crews adequately supervised?
- Is the span of control manageable?

### III. ROLE OF THE FIRST RESPONDER

#### a. Site Control

Access to the incident scene should be controlled as early as possible to prevent unauthorized personnel from entering the site and possibly becoming contaminated.

Once the outer perimeter is established, you should define the possible areas of contamination.

The **Hot Zone** (also referred to as the Hazard Zone, the Restricted Zone or the Exclusion Zone) **is the area in which the hazardous material is actually located.** It is the area of maximum hazard and is restricted to essential personnel using appropriate protective clothing and equipment.

The **Warm Zone** (also called the Transition Zone or the Contamination Reduction Zone) is a transition area between the Hot Zone and Cold Zone (clean area). This area, located away from the hazard, helps prevent contaminants from spreading to unaffected areas. **Decontamination takes place in the Warm Zone and personnel must use protective equipment appropriate to the level of hazard.**

**The Cold Zone is the area beyond the range of potential contamination.** The public is excluded from this area to allow the fire department and other emergency response agencies to function.

### IV. POST-INCIDENT ANALYSIS AND EVALUATION

The post-incident analysis is a key element in improving emergency response to hazardous materials incidents. The analysis may be used by the fire service only, or it may be shared with other agencies, industries, or private contractors that need the information for planning and prevention activities.

## **PRE-INCIDENT PLANNING**

Fire department should begin planning and preparing for hazardous materials incident long before they occur. Through pre-incident planning, hazards can be identified, resources appropriated and personnel trained

### **I. HAZARD IDENTIFICATION**

In order to plan, the types and locations of hazards within the community or jurisdiction must be identified. (Knowledge of topography)

It is essential that all facilities housing hazardous materials be identified and information be obtained on the materials on the premises.

### **II. HAZARD ANALYSIS AND RISK ASSESSMENT**

- Identify the potential for an incident that will cause damage to life, property or the environment
- Identify vulnerable areas
- Analyze the risk or probability of this occurring

### **III. ANALYSIS OF RESOURCE**

Your available resource and training are among the most critical factors that dictate how you handle hazardous materials incidents.

**The right response is working within limitations of resources and training.  
The wrong response is going beyond those limitations.**