HAZARDOUS MATERIALS OPERATIONS

2019

PREFACE

Welcome to the Hazardous Materials - Operations certification course. This course complies with NFPA 472, Standard for Competence of Responders to Hazardous Materials/Weapons of Mass Destruction Incidents, 2018 and with NFPA 1072, Standard for Hazardous Materials/Weapons of Mass Destruction Emergency Response Personnel Professional Qualifications 2017.

Annual refresher training is required for all graduates of this course in accordance with the code of federal regulations. Refresher training must be of sufficient content and duration to maintain their certification, or the graduate shall demonstrate competency in those areas at least yearly (i.e. HazMat exercise, multimedia training, classroom training, or participating in an actual HazMat emergency response). This is a mandatory employer requirement to comply with the law (29 CFR 1910.120-q-6)

The State Emergency Response Commission requires 8 hours per year of continuous education to retain certification per year (i.e. HazMat exercise, multimedia training, classroom training, WMD training or participating in an actual HazMat emergency response).

Hazardous Materials for First Responders Fifth Edition

Chapter 4 — Analyzing the Incident: Identifying Potential Hazards

HAZARDOUS MATERIALS FOR FIRST RESPONDERS
FIFTH EDITION

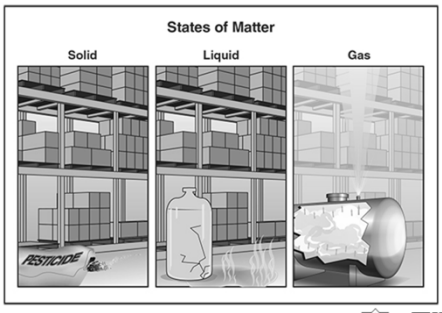
IFSTA

Learning Objective 1

Identify states of matter as they relate to hazardous materials.

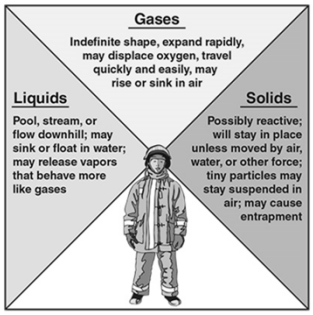
4–1

Matter is found in three states.



4–2

The state of matter can affect how a material behaves.



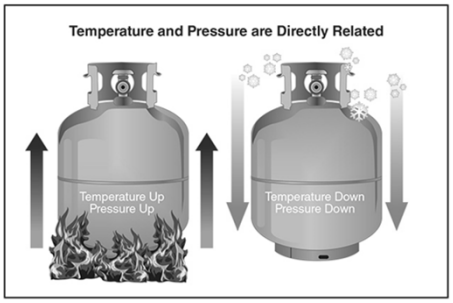
4–3

The ERG establishes initial isolation distances based on matter state.

Initial Isolation Distance	Solids	75 ft (25m)
	Liquids	150 ft (50m)
	Gases	330 ft (100m)

4–4

Temperature strongly influences state of matter and behavior.



4–5

Gases are potentially the most dangerous for responders.

Gas hazards include

- May have an odor
- May be colorless, odorless, and or tasteless
- May be toxic, corrosive, or flammable
- May be under high pressure
- May be extremely cold and/or have a large expansion ratio if liquefied

4–6

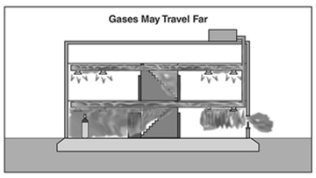
Gases keep expanding if uncontained.

Gas may spread

- Throughout building
- To other buildings
- Through access shafts
- Into the soil
- Into the street

4–7

Gases may travel in unexpected ways.



4–8

Incidents involving gases are often difficult to mitigate.

Large perimeters may be necessary, even for incidents involving small containers

4–9

Gases may require monitoring and detection devices to detect.

4–10

NOTE

Research has shown that 1- and 2-ton quantities of chlorine and anhydrous ammonia released in an open area both initially spread in a 360° radius before being dispersed downwind.

4–11

WARNING

Expanding gases can displace oxygen, creating an asphyxiating atmosphere.

4–12

Gases may present multiple hazards.

Courtesy of Rich Mahaney

4–13

Liquids are usually visible so it is easier to detect their presence and hazards.

4–14

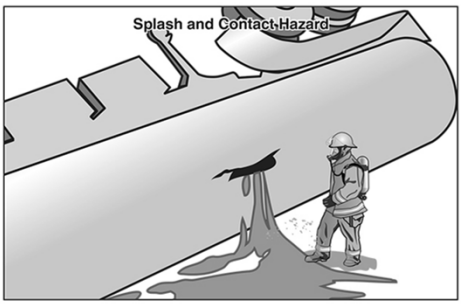
Responders may be able to predict the most likely paths that spilled liquids will follow.

4–15

Because liquids follow topography, they can be contained.

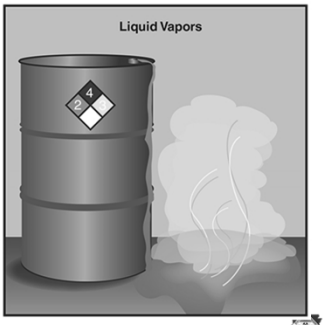
4–16

Liquids also present a splash hazard.



4–17

The vapors from liquids present additional hazards.



4–18

Vapors from liquids may be much more difficult to detect.

Vapors from liquids may be

- Contact hazards
- Inhalation hazards
- Flammable
- Corrosive
- Toxic

4–19

CAUTION

Vapors from liquids behave like gases, and may be flammable, corrosive, or toxic.

4–20

Solids are the least mobile of the three states of matter.

Courtesy of David Alexander with the Texas Commission on Fire Protection

4–21

The particle size of solids may influence their behavior.

4–22

Solids may have multiple hazards.

- Inhalation or contact hazards
- Small, combustible particles, that, if ignited, may explode
- Entrapment hazard
- Flammable
- Reactive
- Radioactive
- Corrosive
- Toxic

4–23

REVIEW QUESTION

What are the different hazards for gases, liquids, and solids?

Learning Objective 2

Explain physical properties that aid in identifying potential hazards and predicting behavior of hazardous materials.

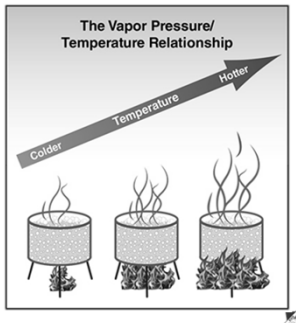
Physical properties do not involve a change in chemical identity.

Materials can be characterized by physical properties	Vapor pressure
	Boiling point
	Melting point/freezing point/sublimation
	Vapor density
	Solubility/miscibility
	Specific gravity
	Persistence
	Appearance and odor

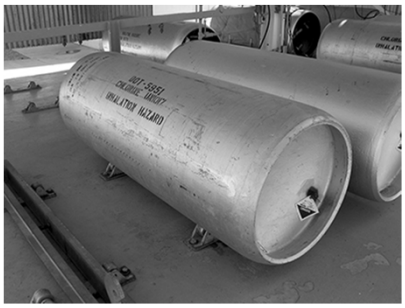
Vapor pressure is the pressure produced or exerted by the vapors of a released liquid.

- Materials with a vapor pressure over 760 mmHg will be gases under normal conditions
- The higher the temperature of a substance, the higher its vapor pressure will be
- Atmospheric pressure is the baseline measurement for pressure
- The lower the boiling point, the higher its vapor pressure will be

A liquid's vapor pressure increases as the temperature rises.



Chlorine's high vapor pressure means that if it escapes, it will be mostly as a gas.

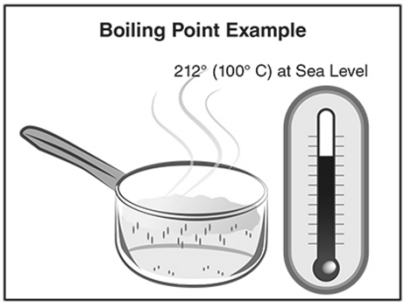


NOTE

Water requires a lot of heat to boil (212°F [100°C]), but some substances boil at room temperature (68°F [20°C]).

4–30

Boiling point is the temperature at which a liquid changes to a gas at a given pressure.



4–31

A BLEVE can cause catastrophic container failure.

- Liquid within a container is heated
- Material inside boils or vaporizes
- If increasing internal vapor pressure exceeds vessel's ability to relieve/retain excess pressure
- Container can fail catastrophically
- As vapor is released it expands rapidly and ignites

4–32

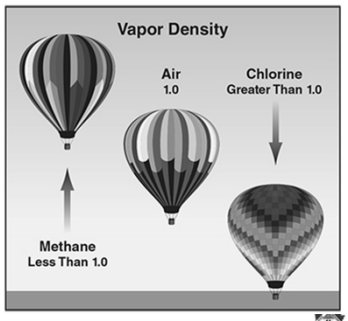
Melting point, freezing point, and sublimation affect hazards.

Dry ice sublimates from a solid into a gas without transitioning into a liquid

4–33

Vapor density affects the weight of gases.

Materials with vapor densities less than one will rise in air



Materials with vapor densities greater than one will sink in air

4–34

Most gases have a vapor density greater than 1.

Common gases with Vapor Density > 1

- Propane
- Hydrogen sulfide
- Ethane
- Butane
- Chlorine
- Sulfur dioxide

4–35

Gases and vapors that are heavier than air may concentrate in low-lying areas.

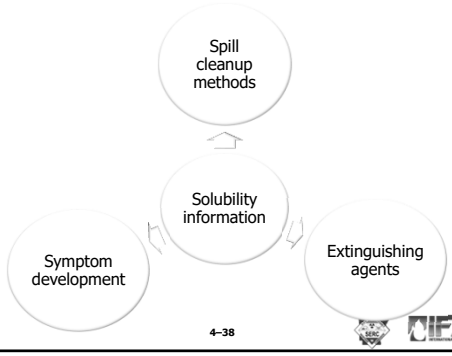
4–36

NOTE

All vapors and gases will mix with air, but the lighter materials (unless confined) tend to rise and dissipate.

4–37

Solubility is the degree to which a material dissolves in water.

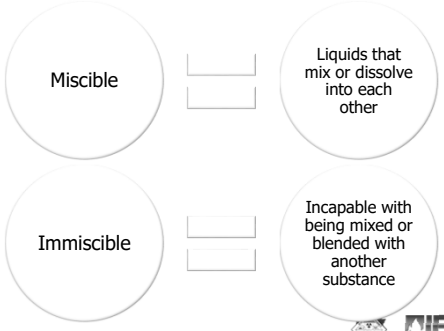


4–38

Hydrocarbons are non-water soluble and do not dissolve in water.

4–39

Miscibility is the ability of two liquids to mix together.



4–40

Because oil is immiscible, it will float on water and could ignite and burn.

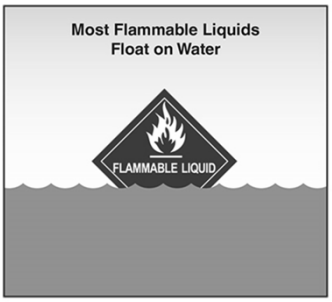
4–41

Materials with a specific gravity greater than one will sink in water.

Specific gravity = The ratio of the density of a material to the density of a standard material

4–42

An important consideration for fire-suppression activities is that most flammable liquids will float on water.



4–43

Persistent chemicals stick around in the environment before dispersing.

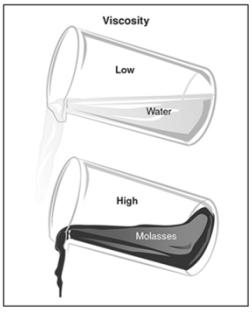
4–44

NOTE

Persistence is not often referenced on an SDS.

4–45

Viscosity is the measure of the thickness or flowability of a liquid at a given temperature.



4–46

The viscosity of materials will affect decontamination or collection.

Viscous materials

- Tend to be more persistent
- May have a lower vapor pressure

4–47

The SDS typically contains a description of a material's appearance.

Change in appearance → May indicate → Change in the behavior of the material

Odorants may be added to some hazardous materials to make them easier to detect.

WARNING

If you can smell a chemical, you are exposed. Move out of the area and reassess the situation.

The ability to smell or sense an odor is highly dependent on the individual.

Never use odors to determine safe or unsafe areas

Some highly toxic products may cause significant damage at a concentration below the odor threshold

Responders spending too much time exposed to some compounds may become desensitized to the smell of a chemical and may no longer be able to determine its presence

REVIEW QUESTION

List the physical properties of materials and explain how they help to determine hazards.

Learning Objective 3

Explain chemical properties that aid in identifying potential hazards and predicting behavior of hazardous materials.

Chemical properties describe behaviors and interactions that occur at a molecular level.

- Flammability
- Corrosivity
- Reactivity
- Radioactivity

4–54

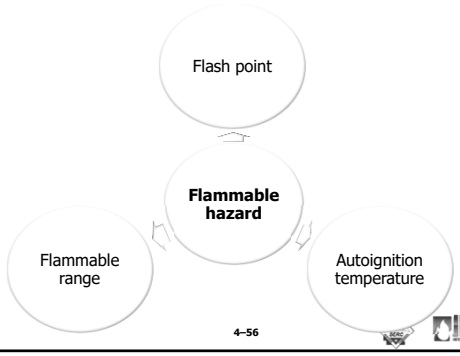
Most hazardous materials incidents involve flammable materials.

Flammable materials can damage life and property when they ignite, burn, or explode

Use a hazard's flammability to help determine incident strategies and tactics

4–55

A flammable hazard depends on properties.



4–56

You must understand flashpoint.

Minimum temperature at which a liquid or volatile solid gives off sufficient vapors at its lower explosive limit (LEL) to form an ignitable mixture with air

=

Flash point

4–57

A material's fire point is usually only a few degrees higher than its flash point.

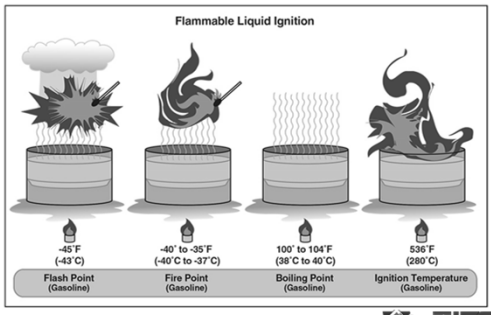
Temperature at which a liquid or volatile substance gives off enough vapors to support continuous burning

=

Fire point

4–58

At its flash point, a material's vapors will flash in the presence of an ignition source but will not continue to burn.



4–59

Autoignition temperature is the point at which a fuel spontaneously ignites.

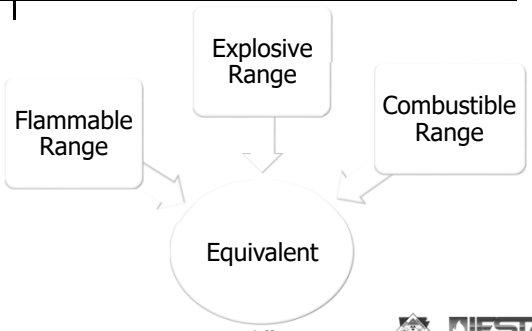
Autoignition or Ignition temperature

Minimum temperature to which the fuel in air must be heated to initiate self-sustained combustion without initiation from an independent ignition source

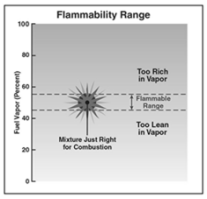
Considerably higher than the flash and fire points

Inflammable is another word for *flammable* in many countries.

The flammable range is the percentage of vapor concentration in the air that will burn or explode if ignited.



A material must fall in the flammability range to burn.



Within the upper and lower limits, the gas or vapor concentration will burn rapidly if ignited.

The upper explosive limit (UEL) or upper flammable limit (UFL)

- Highest concentration that will produce a flash of fire when an ignition source is present

The lower explosive limit (LEL) or lower flammable limit (LFL)

- Lowest concentration that will produce a flash of fire when an ignition source is present

Atmospheres within the flammable range are particularly dangerous.

Table 4.1
Flammable Ranges for Selected Materials

Material	Lower Flammable Limit (LFL) (percent by volume)	Upper Flammable Limit (UFL) (percent by volume)
Acetylene	2.5	100.0
Carbon Monoxide	12.5	74.0
Ethyl Alcohol	3.3	19.0
Fuel Oil No. 1	0.7	5.0
Gasoline	1.4	7.6
Methane	5.0	15.0
Propane	2.1	9.5

Source: *NIOSH Pocket Guide to Chemical Hazards*

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

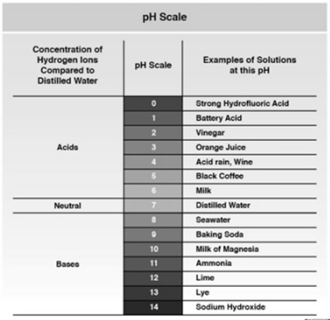
Corrosives

Commonly divided into two broad categories
- Acids
- Bases

Measured or expressed in terms of pH

4–66

pH measures the acidity or alkalinity of a solution.



4–67

An acid dissociates to yield hydrogen ions in water.

- pH values of 0 to 6.9
- May cause severe chemical burns to flesh and permanent eye damage
- Contact typically causes immediate pain
- Examples include hydrochloric acid, nitric acid, sulfuric acid

4–68

A base dissociates to yield hydroxide ions in water.

- pH values of 7.1 to 14
- Breaks down fatty skin tissues and can penetrate deeply into the body
- Examples include caustic soda, potassium hydroxide, and other alkaline materials commonly used in drain cleaners

4–69

Bases can cause severe eye and tissue damage.

Bases tend to adhere to the tissues in the eye
- Makes them difficult to remove
- Longer exposure means that bases often cause more eye damage than acids

Contact with a base does not normally cause immediate pain
- A common sign of exposure to a base is a greasy or slick feeling of the skin
- Caused by breakdown of fatty tissues (saponification)

4–70

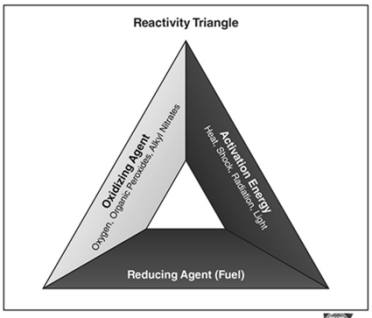
The chemical reactivity of a substance describes its relative ability to undergo a chemical reaction.

Reactive materials commonly react vigorously or violently with air, water, heat, light, each other, or other materials

May result in pressure buildup, temperature increase, and/or formation of noxious, toxic, or corrosive by-products

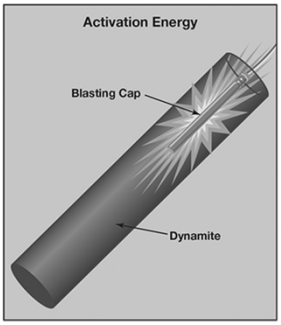
4–71

Many reactions need an oxidizing agent, a reducing agent, and activation energy to get started.



4–72

Activation energy is the energy needed to start a reaction.



4–73

There are nine reactive hazard classes.

Highly flammable	Explosive	Polymerizable
Strong oxidizing agent	Strong reducing agent	Water-reactive
Air-reactive	Peroxidizable compound	Radioactive material

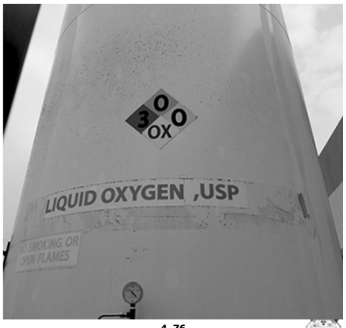
4–74

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

- **Strong oxidizers** are materials that encourage a strong reaction (by readily accepting electrons) from reducing agents (fuels)
- In general, the stronger the oxidizer, the stronger the reaction
- Many organic materials ignite spontaneously when they come into contact with a strong oxidizer

4–75

If spilled on asphalt, liquid oxygen could cause an explosion.



4–76

Table 4.2
Nine Reactive Hazard Classes

Reactive Hazard Class	Definition	Chemical Examples
Highly Flammable	Substances having flash points less than 100°F (38°C) and mixtures that include substances with flash points less than 100°F (38°C).	Gasoline, Acetone, Pentane, Ethyl Ether, Toluene, Methyl Ethyl Ketone (MEK), Turpentine
Explosive	A material synthesized or mixed deliberately to allow the very rapid release of chemical energy; also, a chemical substance that is intrinsically unstable and liable to detonate under conditions that might reasonably be encountered.	Dynamite, Nitroglycerin, Perchloric Acid, Picric Acid, Fulminates, Azide
Polymerizable	Capable of undergoing self-reactions that release energy; some polymerization reactions generate a great deal of heat. (The products of polymerization reactions are generally less reactive than the starting materials.)	Acrylic Acid, Butadiene, Ethylene, Styrene, Vinyl Chloride, Epoxies
Strong Oxidizing Agent	Oxidizing agents gain electrons from other substances and are themselves thereby chemically reduced, but strong oxidizing agents accept electrons particularly well from a large range of other substances. The ensuing oxidation-reduction reactions may be vigorous or violent and may release new substances that may take part in further additional reactions. Keep strong oxidizing agents well separated from strong reducing agents. In some cases, the presence of a strong oxidizing agent can greatly enhance the progress of a fire.	Hydrogen Peroxide, Fluorine, Bromine, Calcium Chlorate, Chromic Acid, Ammonium Perchlorate
Strong Reducing Agent	Reducing agents give up electrons to other substances and are thereby oxidized, but strong reducing agents donate electrons particularly well to a large range of other substances. The ensuing oxidation-reduction reactions may be vigorous or violent and may generate new substances that take part in further additional reactions.	Alkali metals (Sodium, Magnesium, Lithium, Potassium), Beryllium, Calcium, Barium, Phosphorus, Radium, Lithium Aluminum Hydride
Water-Reactive	Substances that may react rapidly or violently with liquid water and steam, producing heat (or fire) and often toxic reaction products.	Alkali metals (Sodium, Magnesium, Lithium, Potassium), Sodium Peroxide, Anhydrides, Carbides
Air-Reactive	Likely to react rapidly or violently with dry air or moist air; may generate toxic and corrosive fumes upon exposure to air or catch fire.	Finely divided metal dusts (Nickel, Zinc, Titanium), Alkali metals (Sodium, Magnesium, Lithium, Potassium), Hydrides (Diborane, Barium Hydrides, Diisobutyl Aluminum Hydride)
Peroxidizable Compound	Apt to undergo spontaneous reaction with oxygen at room temperature, to form peroxides and other products. Most such auto-oxidations are accelerated by light or trace impurities. Many peroxides are explosive, which makes peroxidizable compounds a particular hazard. Ethers and aldehydes are particularly subject to peroxide formation (the peroxides generally form slowly after evaporation of the solvent in which a peroxidizable material had been stored).	Isopropyl Ether, Furan, Acrylic Acid, Styrene, Vinyl Chloride, Methyl Isobutyl Ketone, Ethers, Aldehydes
Radioactive Material	Spontaneously and continuously emitting ions or ionizing radiation. Radioactivity is not a chemical property, but an additional hazard that exists in addition to the chemical properties of a material.	Radon, Uranium

Source: U.S. Environmental Protection Agency's CEPPO (Chemical Emergency Preparedness and Prevention Office) Computer-Aided Management of Emergency Operations (CAMEO) software was used to identify this information.

The reducing agent acts as the fuel source for the reaction.

Reducing agent → Combines with oxygen → Energy is released

Some reducing agents (fuels) are more volatile than others

NOTE

Wood is not as prone to undergo rapid oxidation (it will not burn as easily) as a highly flammable liquid such as MEK.

Polymerization is a chemical reaction that forms long chain molecules.

Polymerization

- Simple molecules form long chain molecules
- Rate increased by catalyst
  - Catalyst decreases activation energy needed
  - Examples of catalysts include light, heat, water, acids, or other chemicals

Uncontrolled polymerization often results in a tremendous release of energy.

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

Materials that may undergo violent polymerization if subjected to heat or contamination are designated with a *P* in the blue and yellow sections of the *ERG*

NOTE

Potential for polymerization may not be included on any type of reference material other than the *ERG*, and the ERG may not be fully inclusive of all polymerizing materials.

Inhibitors are materials that are added to products to control an undesired reaction.

Inhibitors

- Added to products that easily polymerize in order to control or prevent an undesired reaction
- Increase the needed activation energy
- May be exhausted over a period of time or when exposed to circumstances or unexpected contamination that causes them to be consumed more rapidly

Shipments of polymerizing materials may become unstable.

Time-sensitive inhibitors are added to liquid styrene before it is shipped

4–83

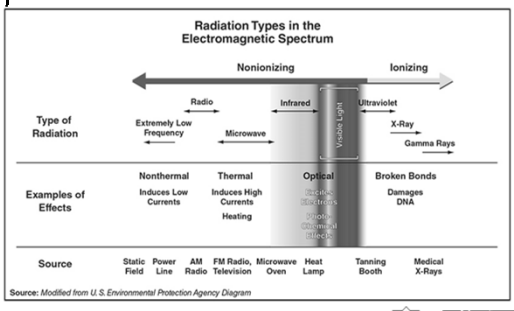
Reactive materials can be extremely destructive and dangerous.

With advances in modern technology, more reactive and unstable materials are being used for various processes, and you must be prepared to deal with them

Keep people and equipment upwind, uphill, and back a safe distance or in protected locations until pertinent facts are established and definite plans can be formulated

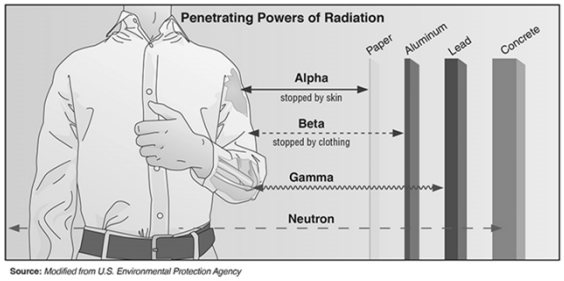
4–84

Radiation comes in different forms, some more energetic than others.



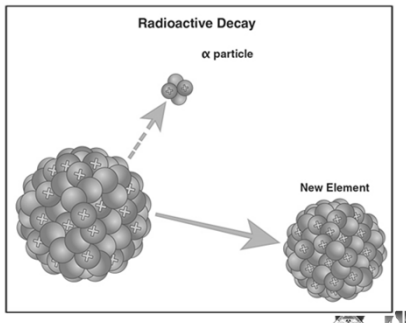
4–85

There are four types of ionizing radiation.



4–86

During radioactive decay, alpha particles are emitted from the nucleus of an atom.



4–87

Alpha particles do not travel far in open air.

Alpha particles	Lose energy rapidly when travelling through matter
	Do not penetrate deeply
	Usually completely blocked by the outer, dead layer of the human skin
	Not a hazard outside the body
	Can be very harmful if ingested or inhaled

4–88

Beta particles travel farther and faster than alpha particles.

Beta particles	Fast-moving, positively charged protons or negatively charged electrons
	Emitted from the atom's nucleus during radioactive decay
	Human exposure from manufactured and natural sources such as tritium, carbon-14, and strontium-90
	Most hazardous when inhaled or ingested

4–89

Beta particles penetrate further than alpha particles, but cause less damage.

Beta particles	Travel appreciable distances in air
	Can be reduced or stopped by a layer of clothing, a thin sheet of metal, or thick Plexiglass
	Detection distances for beta particles vary based on the activity of the source
	Compared to alpha radiation, beta radiation will travel farther
	Shielding beta emitters with dense metals can result in the release of X-rays

4–90

Gamma particles are high energy photons.

Gamma rays	Often accompany the emission of alpha or beta particles from a nucleus
	Have neither a charge nor a mass but are penetrating
	Can easily pass completely through the human body or be absorbed by tissue
	Constitutes a radiation hazard for the entire body

4–91

Gamma exposure sources include both natural and industrial.

- Gamma radiation levels vary depending on the isotope and activity
- Materials such as concrete, earth, and lead may be useful as a shield against radiation
- Standard fire fighting protective clothing provides no protection against gamma radiation

4–92

Activity refers to the number of atoms in a radioactive material that will decay and emit radiation in a second.

4–93

Neutron particles have a physical mass but no electrical charge.

Neutrons	Highly penetrating
	Produced in fission reactions
	Can be measured in the field using specialized equipment
	Sources include moisture density gauges, research laboratories, and operating nuclear power plants
	Shielding from neutron radiation requires materials with high amounts of hydrogen, such as oil, water, and concrete

4–94

X-rays and gamma rays are high energy radiation called photons.

- Hazards directly correlated to their activity
- Machines such as those found in medical facilities and airports are almost exclusively the sole source of terrestrial X-ray radiation
- Since machines can only produce X-rays when powered on, the chances of encountering X-rays at a hazardous materials incident are remote

4–95

Radioactive materials could be used in a terrorist attack.

4–96

Radiation exposure occurs when a person near a radiation source is exposed to energy from that source.

- A person may receive a dose of radiation based upon the length of exposure, energy, and type of source
- Damage is often described in terms of dosage, indicating the amount of energy absorbed

4–97

A first responder will need to know what proximity or level of exposure will cause what kinds of harm.

4–98

Radioactive contamination occurs when radioactive material is deposited any place where it is not desired.

Exposure to radiation alone does not contaminate a person

Contamination only occurs when the radioactive material remains on a person or the person's clothing after coming into contact with a contaminant

A person can become contaminated externally, internally, or both

4–99

Radioactive contamination can spread.

An unprotected person contaminated with radioactive material receives radiation exposure until the source of radiation (radioactive material) is removed

Radiation detectors capable of detecting alpha and beta contamination can detect radioactive contamination

4–100

NOTE

Some contamination, such as alpha contamination, often requires the detector to be almost touching the source.

The effects of ionizing radiation occur at the cellular level.

- Radiation may cause damage to any material by ionizing the atoms in that material
- When atoms are ionized, the chemical properties of those atoms are altered
- This can result in a change in the chemical behavior of the atoms and/or molecules in the cell
- A sufficiently high dose of radiation can damage many cells
- May cause observable health effects, including genetic mutations and cancer

An acute radiation dose is received in a short period of time.

Acute doses	Received in a short period – Usually a large dose
	Can produce serious health effects, including reduced blood count, hair loss, nausea, vomiting, diarrhea, and fatigue
	Extremely high levels of acute radiation exposure can result in death within a few hours, days, or weeks

A chronic radiation dose is received over a long period of time.

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

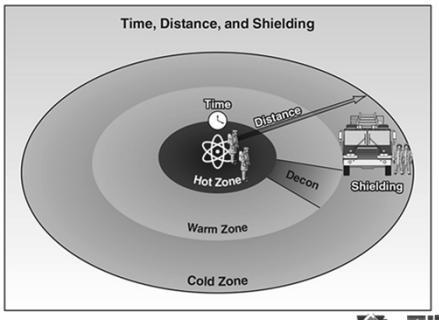
It is unlikely that first responders will encounter dangerous or lethal doses of radiation.

Courtesy of the U.S. Department of Energy

The presence of radiation placards at an incident should trigger radiation detection and monitoring plans.

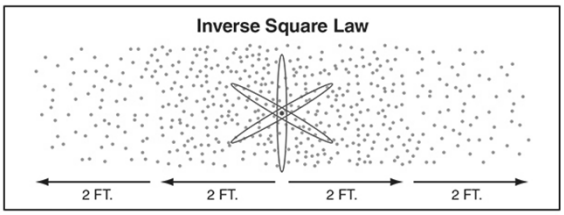
Courtesy of Rich Mahaney

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



4–107

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



4–108

NOTE

Using time, distance, and shielding to limit exposure to radiation is sometimes referred to as the ALARA (As Low As Reasonably Achievable) method or principle.

4–109

CAUTION

Limit your time to limit the dose!

Maximize your distance to limit the dose!

Use shielding to limit your dose!

4–110

The degree to which a substance causes harm within the body is called its toxicity.

Local toxic effect	Systemic effects
• A chemical injury at the site of contact (typically the skin and mucous membranes of the eyes, nose, mouth, or respiratory tract)	• Toxic materials may be absorbed into the bloodstream and distributed to other parts of the body • Multiple systemic effects are possible

4–111

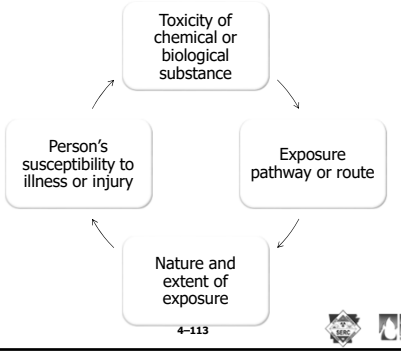
Different chemicals affect different parts of the body.

Table 4.3
Types of Toxicants and Their Target Organs

Toxin	Targets	Chemical Examples
Nephrotoxicant	Kidney	Halogenated Hydrocarbons, Mercury, Carbon Tetrachloride
Hemotoxicant	Blood	Carbon Monoxide, Cyanides, Benzene, Nitrates, Arsine, Naphthalene, Cocaine
Neurotoxicant	Nervous System	Organophosphates, Mercury, Carbon Disulphide, Carbon Monoxide, Sarin
Hepartoxicant	Liver	Alcohol, Carbon Tetrachloride, Trichloroethylene, Vinyl Chloride, Chlorinated HC
Immunotoxicant	Immune System	Benzene, Polybrominated Biphenyls (PBBs), Polychlorinated Biphenyls (PCBs), Dioxins, Dieldrin
Endocrine Toxicant	Endocrine System (including the pituitary, hypothalamus, thyroid adrenals, pancreas, thymus, ovaries, and testes)	Benzene, Cadmium, Chlordane, Chloroform, Ethanol, Kerosene, Iodine, Parathion
Musculoskeletal Toxicant	Muscles/Bones	Fluorides, Sulfuric Acid, Phosphine
Respiratory Toxicant	Lungs	Hydrogen Sulfide, Xylene, Ammonia, Boric Acid, Chlorine
Cutaneous Hazards	Skin	Gasoline, Xylene, Ketones, Chlorinated Compounds
Eye Hazards	Eyes	Organic Solvents, Corrosives, Acids
Mutagens	DNA	Aluminum Chloride, Beryllium, Dioxins
Teratogens	Embryo/Fetus	Lead, Lead Compounds, Benzene
Carcinogens	All	Tobacco Smoke, Benzene, Arsenic, Radon, Vinyl Chloride

4–112

Toxic health effects depend on multiple factors.



4–113

CAUTION

All personnel working at hazardous materials incidents must use appropriate personal protective equipment, including appropriate respiratory protection equipment.

4–114

Table 4.3
Types of Toxicants and Their Target Organs

Toxin	Targets	Chemical Examples
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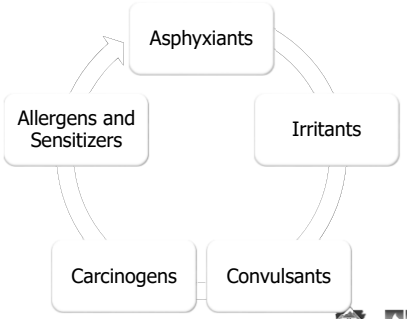
Eye Hazards	Eyes	Organic Solvents, Corrosives, Acids
Mutagens	DNA	Aluminum Chloride, Beryllium, Dioxins
Teratogens	Embryo/Fetus	Lead, Lead Compounds, Benzene
Carcinogens	All	Tobacco Smoke, Benzene, Arsenic, Radon, Vinyl Chloride

There are many toxic chemical hazard categories.



4–115

Asphyxiants prevent access to sufficient volumes of oxygen.

4–116

Irritants cause temporary, sometimes severe, inflammation.

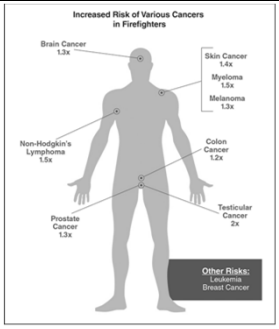
Courtesy of Rich Mahaney

4–117

Convulsants cause convulsions and can kill the victim.

4–118

Carcinogens are known, or suspected, to cause cancer.



4–119

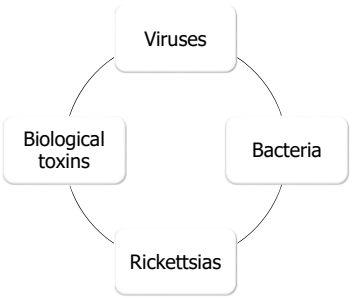
Individuals exposed to a material may experience effects after one or multiple exposures.

Allergens cause allergic reactions

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

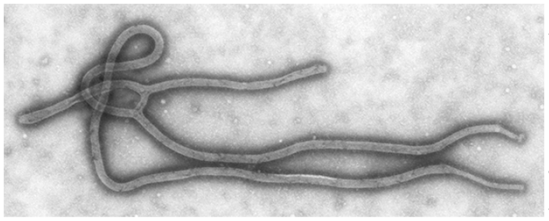
4–120

Biological (*etiological*) hazards may cause severe, disabling disease or illness.



4–121

Viruses are the simplest types of microorganisms.



Courtesy of the CDC Public Health Image Library

4–122

Table 4.4
Common Products of Combustion and Their Toxic Effects

Acetaldehyde	Colorless liquid with a pungent choking odor, which is irritating to the mucous membranes and especially the eyes. Breathing vapors will cause nausea, vomiting, headache and unconsciousness.
Acrolein	Colorless to yellow volatile liquid with a disagreeable choking odor, this material is irritating to the eyes and mucous membranes. This substance is extremely toxic; inhalation of concentrations as little as 10 ppm may be fatal within a few minutes.
Asbestos	A magnesium silicate mineral that occurs as slender, strong flexible fibers. Breathing of asbestos dust causes asbestosis and lung cancer.
Benzene	Colorless liquid with a petroleum-like odor. Acute exposure to benzene can result in dizziness, excitation, headache, difficulty breathing, nausea and vomiting. Benzene is also a carcinogen.
Benzaldehyde	Colorless to clear yellow liquid with a bitter almond odor. Inhalation of concentrated vapor is irritating to the eyes, nose, and throat.
Carbon Monoxide	Colorless, odorless gas. Inhalation of carbon monoxide causes headache, dizziness, weakness, confusion, nausea, unconsciousness, and death. Exposure to as little as 0.2% carbon monoxide can result in unconsciousness within 30 minutes. Inhalation of high concentration can result in immediate collapse and unconsciousness.
Formaldehyde	Colorless gas with a pungent irritating odor that is highly irritating to the nose. 50-100 ppm can cause severe irritation to the respiratory track and serious injury. Exposure to high concentrations can cause injury to the skin. Formaldehyde is a suspected carcinogen.
Glutaraldehyde	Light yellow liquid that causes severe irritation of the eyes and irritation of the skin.
Hydrogen Chloride	Colorless gas with a sharp, pungent odor. Mixes with water to form hydrochloric acid. Hydrogen chloride is corrosive to human tissue. Exposure to hydrogen chloride can result in irritation of skin and respiratory distress.
Isovaleraldehyde	Colorless liquid with a weak, suffocating odor. Inhalation causes respiratory distress, nausea, vomiting and headache.
Nitrogen Dioxide	Reddish brown gas or yellowish-brown liquid, which is highly toxic and corrosive.
Particulates	Small particles that can be inhaled and be deposited in the mouth, trachea, or the lungs. Exposure to particulates can cause eye irritation, respiratory distress (in addition to health hazards specifically related to the particular substances involved).
Polycyclic Aromatic Hydrocarbons (PAH)	PAH are a group of over 100 different chemicals that generally occur as complex mixtures as part of the combustion process. These materials are generally colorless, white, or pale yellow-green solids with pleasant odor. Some of these materials are human carcinogens.
Sulfur Dioxide	Colorless gas with a choking or suffocating odor. Sulfur dioxide is toxic and corrosive and can irritate the eyes and mucous membranes.

Source: *Computer Aided Management of Emergency Operations (CAMEO) and Toxicological Profile for Polycyclic Aromatic Hydrocarbons.*

Bacteria are microscopic, single-celled organisms.

Courtesy of the CDC Public Health Image Library

4–123

Rickettsias are specialized bacteria that live and multiply in arthropod carriers (such as ticks and fleas).

Courtesy of the U.S. Department of Agriculture

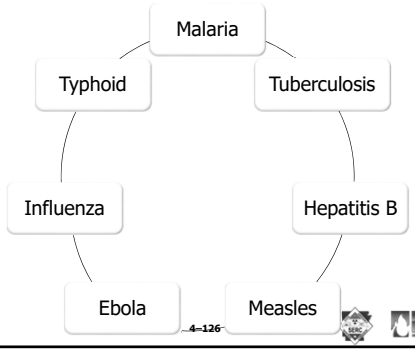
4–124

Biological toxins are produced by living organisms.

Ricin, a biological toxin, is made from castor beans

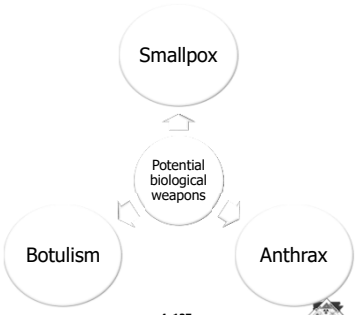
4–125

Many diseases are considered biological hazards.



4–126

Biological agents may be used as weapons in terrorist attacks or criminal activities.



4–127

REVIEW QUESTION

List the chemical properties of materials and explain how they help to determine hazards.

4–128

Learning Objective 4

Define the hazard classes.

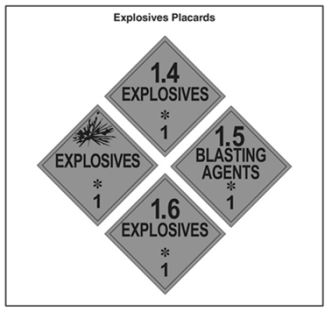
4–129

There are nine transportation hazard classes.

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

4–130

Explosives are reactive and may release energy.



4–131

Explosive placards list both a division number and a compatibility group letter.

Courtesy of Rich Mahaney

4–132

Certain containers and storage areas are specifically designed for explosives.

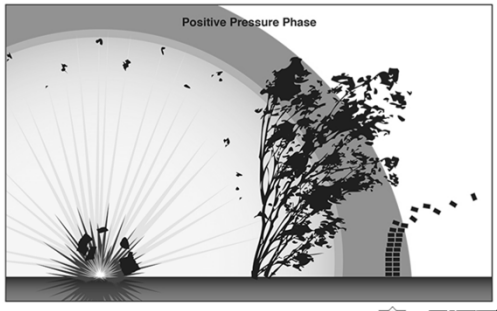
4–133

Rapidly released gases can create a blast-pressure wave (shock wave).

- Travels outward from the center
- As the wave increases in distance, the strength decreases
- Primary reason for injuries and damage
- Positive and negative phase, both can cause damage

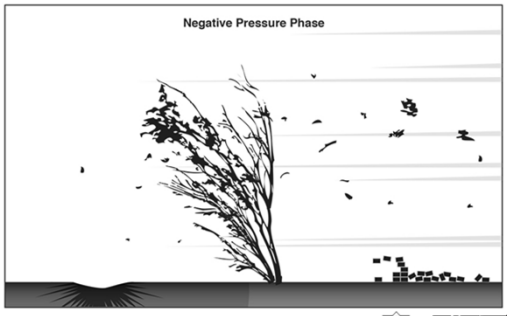
4–134

The positive pressure wave can be extremely destructive.



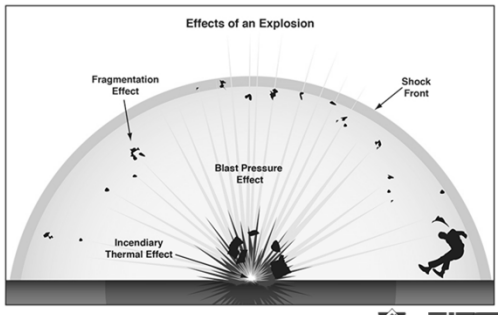
4–135

Additional damage can be done during the negative pressure phase.



4–136

There are multiple effects of an explosion that can cause damage.



4–137

Shrapnel and fragmentation may be thrown over a wide area.

Small pieces of debris thrown from a container or structure that ruptures during an explosion from containment or restricted blast pressure

May cause personal injury and other types of damage to surrounding structures or objects

Can result in bruises, punctures, or even avulsions (part of the body being torn away) when they strike a person

4–138

Explosions can cause a seismic effect.

When a blast occurs at or near ground level, the air blast creates a ground shock or crater

As the shock waves move across or underground, they form a seismic disturbance

The distance the shock wave travels depends on the type and size of the explosion and type of soil

4–139

The incendiary thermal effect occurs when a fireball is formed during and explosion.

Fireballs

- Result from interactions among burning combustible gases or flammable vapors and ambient air at high temperatures
- Present for a limited time after explosive event

4–140

There are additional hazards unrelated to the explosion.

- Chemical hazards will probably result from production of toxic gases and vapors
- Explosives may self-contaminate as they age, which increases their sensitivity and instability
- Explosives may have high sensitivity to shock and friction

4–141

DOT divides Class 1 into six divisions.

Table 4.5
Class 1 Divisions

Division Number	Definition	Examples
Division 1.1	Explosives that have a mass explosion hazard. A mass explosion is one that affects almost the entire load instantaneously.	Dynamite, mines, wetted mercury fulminate
Division 1.2	Explosives that have a projection hazard but not a mass explosion hazard.	Detonation cord, rockets (with bursting charge), flares, fireworks
Division 1.3	Explosives that have a fire hazard and either a minor blast hazard or a minor projection hazard or both. Not a mass explosion hazard.	Liquid-fueled rocket motors, smokeless powder, practice grenades, aerial flares

4–142

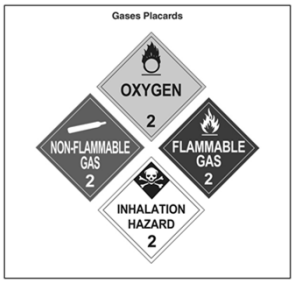
DOT divides Class 1 into six divisions.

Division 1.4	Explosives that present a minor explosion hazard. The explosive effects are largely confined to the package and no projection of fragments of appreciable size or range is expected. An external fire must not cause virtually instantaneous explosion of almost the entire contents of the package.	Signal cartridges, cap type primers, igniter fuses, fireworks
Division 1.5	Substances that have a mass explosion hazard but are so insensitive that there is little probability of initiation or of transition from burning to detonation under normal transportation conditions.	Prilled ammonium nitrate fertilizer or fuel oil (ANFO) mixtures and blasting agents
Division 1.6	Extremely insensitive articles that do not have a mass explosive hazard. This division is comprised of articles that contain only extremely insensitive detonating substances and that demonstrate a negligible probability of accidental initiation or propagation.	Wetted cellulose nitrate, low vulnerability military weapons

Source: *49* CFR *173.50*

4–143

Gases are materials that are in a gaseous state at normal temperatures and pressures.

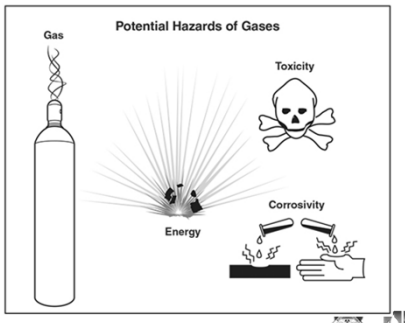


4–144

Gases are transported or stored in pressure containers or cryogenic containers.

4–145

Gas division numbers are assigned according to the type of potential hazard.



4–146

Gases have other hazards as well.

Heat hazards — Fires, particularly associated with Division 2.1 and oxygen

Asphyxiation hazards — Leaking or released gases displacing oxygen in a confined space

Cold hazards — Exposure to Division 2.2 cryogens

Mechanical hazards — A BLEVE (boiling liquid expanding vapor explosion) for containers exposed to heat or flame; a ruptured cylinder rocketing after exposure to heat or flame

Chemical hazards — Toxic and/or corrosive gases and vapors

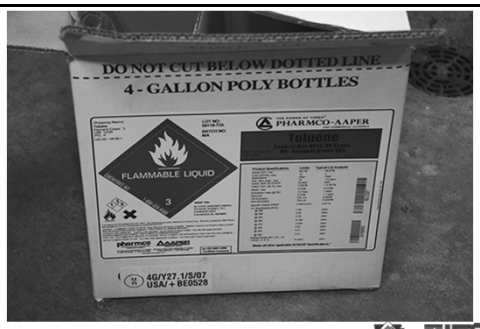
There are multiple Class 2 divisions and placards.

Table 4.6
Class 2 Divisions, Placards, Definitions, and Examples

Division Number and Placard	Definition
Division 2.1 	**Flammable Gas** — Consists of any material that is a gas at 68°F (20°C) or less at normal atmospheric pressure or a material that has a boiling point of 68°F (20°C) or less at normal atmospheric pressure and that (1) Is ignitable at normal atmospheric pressure when in a mixture of 13 percent or less by volume with air, or (2) Has a flammable range at normal atmospheric pressure with air of at least 12 percent, regardless of the lower limit. *Examples:* compressed hydrogen, isobutene, methane, and propane
Division 2.2 	**Nonflammable, Nonpoisonous Gas** — Nonflammable, nonpoisonous compressed gas, including compressed gas, liquefied gas, pressurized cryogenic gas, and compressed gas in solution, asphyxiant gas and oxidizing gas; means any material (or mixture) which exerts in the packaging an absolute pressure of 40.6 psi (280 kPa) or greater at 68°F (20°C) and does not meet the definition of Divisions 2.1 or 2.3. *Examples:* carbon dioxide, helium, compressed neon, refrigerated liquid nitrogen, cryogenic argon
Division 2.3 	**Gas Poisonous by Inhalation** — Material that is a gas at 68°F (20°C) or less and a pressure of 14.7 psi (101.3 kPa) (a material that has a boiling point of 68°F [20°C] or less at 14.7 psi [101.3 kPa]), and that is known to be so toxic to humans as to pose a hazard to health during transportation; or (in the absence of adequate data on human toxicity) is presumed to be toxic to humans because of specific test criteria on laboratory animals. Division 2.3 has *ERG*-designated hazard zones associated with it, determined by the concentration of gas in the air: • Hazard Zone A — LC50 less than or equal to 200 ppm • Hazard Zone B — LC50 greater than 200 ppm and less than or equal to 1,000 ppm • Hazard Zone C — LC50 greater than 1,000 ppm and less than or equal to 3,000 ppm • Hazard Zone D — LC50 greater than 3,000 ppm and less than or equal to 5,000 ppm *Examples:* cyanide, diphosgene, germane, phosphine, selenium hexafluoride, and hydrocyanic acid
	Oxygen Placard — Oxygen is not a separate division under Class 2, but first responders may see this oxygen placard on containers with 1,001 lbs (454 kg) or more gross weight of either compressed gas or refrigerated liquid. 

Source: *49 CFR 173.115*

Flammable and combustible liquids ignite and burn with relative ease.



Most hazmat incidents involve Class 3 materials.

All flammable and combustible liquids exhibit varying degrees of toxicity

Some flammable liquids are also corrosive

In most conditions, Class 3 materials will give off flammable vapors that behave much like gases.

The primary hazards of flammable and combustible liquids are energy, corrosivity, and toxicity.

Thermal hazards (heat) — Fires and vapor explosions

Asphyxiation — Heavier-than-air vapors displacing oxygen in low-lying and/or confined spaces

Chemical hazards — Toxic and/or corrosive gases and vapors; these may be produced by fires

Mechanical hazards — A BLEVE, for containers exposed to heat or flame; caused by a vapor explosion

Vapors — Can mix with air and travel great distances to an ignition source

Environmental hazards (pollution) — Caused by runoff from fire control

Flammability is the primary hazard for Class 3 materials.

Courtesy of Williams Fire & Hazard Control Inc., Brent Gaspard

4–153

There are multiple Class 3 divisions and placards.

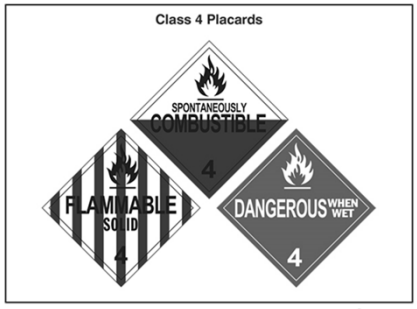
Table 4.7
Class 3 Divisions, Placards, Definitions, and Examples

Placard	Definition
FLAMMABLE 3	**Flammable** A flammable liquid is generally a liquid having a flash point of not more than 140°F (60°C), or any material in a liquid state with a flash point at or above 100°F (37.8°C) that is intentionally heated and offered for transportation or transported at or above its flash point in a bulk packaging. *Examples:* gasoline, methyl ethyl ketone
GASOLINE 3	**Gasoline Placard** — May be used in the place of a flammable placard on a cargo tank or a portable tank being used to transport gasoline by highway
COMBUSTIBLE 3	**Combustible** A combustible liquid is any liquid that does not meet the definition of any other hazard class and has a flash point above 140°F (60°C) and below 200 °F (93 °C). A flammable liquid with a flash point at or above 100°F (37.8°C) that does not meet the definition of any other hazard class may be reclassified as a combustible liquid. This provision does not apply to transportation by vessel or aircraft, except where other means of transportation is impracticable. An elevated temperature material that meets the definition of a Class 3 material because it is intentionally heated and offered for transportation or transported at or above its flash point may not be reclassified as a combustible liquid. *Examples:* diesel, fuel oils, pine oil
FUEL OIL 3	**Fuel Oil Placard** — May be used in place of a combustible placard on a cargo tank or portable tank being used to transport fuel oil by highway *Examples:* Bunker fuel, heating fuel

Source: 49 CFR 173.120

4–154

Class 4 materials are divided into three divisions.



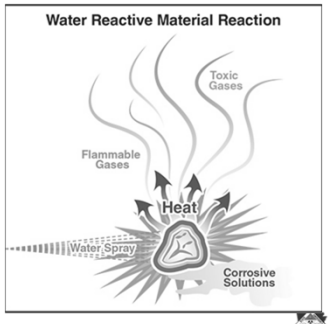
4–155

Class 4 materials are often solids that react violently in unexpected ways and may be difficult to extinguish.

- Some flammable solids will react to friction
- Spontaneously combustible materials may ignite after contact with air
- Dangerous when wet materials, if involved in a fire, may burn more intensely if firefighters attempt to extinguish the fire with water

4–156

Some Class 4 materials react violently when contacted by water.



4–157

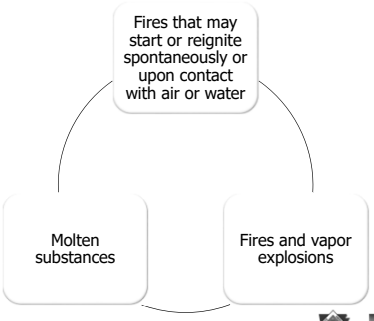
Incidents involving Class 4 materials can be difficult to manage.

Even more experienced responders may not fully understand the hazards

Typical response may make the situation worse

4–158

There are thermal hazards to Class 4 materials.



4–159

Other hazards of these materials include chemical energy, mechanical energy, corrosivity, and toxicity.

- Chemical hazards from irritating, corrosive, and/or highly toxic gases and vapors produced by fire or decomposition
- Severe chemical burns
- Mechanical effects from a BLEVE or other unexpected, violent chemical reactions and explosions
- Chemical hazards from production of various chemicals
- Environmental hazards (pollution) caused by runoff from fire control

4–160

There are multiple Class 4 divisions and placards.

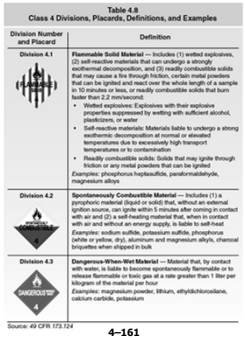


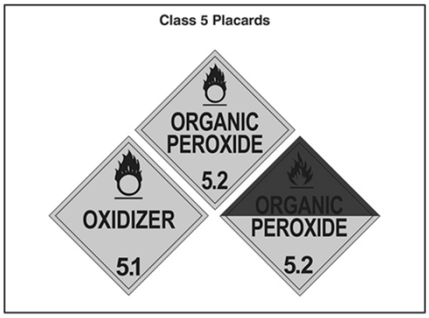
Table 4.8
Class 4 Divisions, Placards, Definitions, and Examples

Division Number and Placard	Definition
Division 4.1	**Flammable Solid Material** — Includes (1) wetted explosives, (2) self-reactive materials that can undergo a strongly exothermal decomposition, and (3) readily combustible solids that may cause a fire through friction, certain metal powders that can be ignited and react over the whole length of a sample in 10 minutes or less, or readily combustible solids that burn faster than 2.2 mm/second: • Wetted explosives: Explosives with their explosive properties suppressed by wetting with sufficient alcohol, plasticizers, or water • Self-reactive materials: Materials liable to undergo a strong exothermic decomposition at normal or elevated temperatures due to excessively high transport temperatures or to contamination • Readily combustible solids: Solids that may ignite through friction or any metal powders that can be ignited *Examples:* phosphorus heptasulfide, paraformaldehyde, magnesium alloys
Division 4.2	**Spontaneously Combustible Material** — Includes (1) a pyrophoric material (liquid or solid) that, without an external ignition source, can ignite within 5 minutes after coming in contact with air and (2) a self-heating material that, when in contact with air and without an energy supply, is liable to self-heat *Examples:* sodium sulfide, potassium sulfide, phosphorus (white or yellow, dry), aluminum and magnesium alkyls, charcoal briquettes when shipped in bulk
Division 4.3	**Dangerous-When-Wet Material** — Material that, by contact with water, is liable to become spontaneously flammable or to release flammable or toxic gas at a rate greater than 1 liter per kilogram of the material per hour *Examples:* magnesium powder, lithium, ethyldichlorosilane, calcium carbide, potassium

Source: 49 CFR 173.124

4–161

Class 5, Oxidizers and Organic Peroxides, is divided into two divisions.



4–162

Oxidizers vigorously support combustion, may be explosive, and, may burn continuously.

4–163

Organic peroxides are oxidizers that are prone to reactivity.

If organic peroxides reach the self-accelerating decomposition temperature (SADT)

They undergo a chemical change and may violently release from their packaging

4–164

WARNING

Immediately evacuate the area if the SADT is reached. If decomposition occurs, observe it from a safe distance and take only those measures necessary to preserve life and nearby property.

4–165

The primary hazards of Class 5 materials are thermal, mechanical, and chemical.

- Thermal hazards (heat) from fires that may explode or burn hot and fast or materials'/substances' sensitivity to heat, friction, shock, and contamination
- Explosive reactions to contact with hydrocarbons (fuels)
- Mechanical hazards such as violent reactions and explosions as well as sensitivity to heat, friction, shock, and/or contamination
- Chemical hazards from toxic gases, vapors, dust, or from products of combustion resulting in burns
- Thermal hazards from ignition of combustibles
- Asphyxiation hazards from accumulation of toxic fumes and dusts in confined spaces

4–166

There are multiple Class 5 divisions and placards.

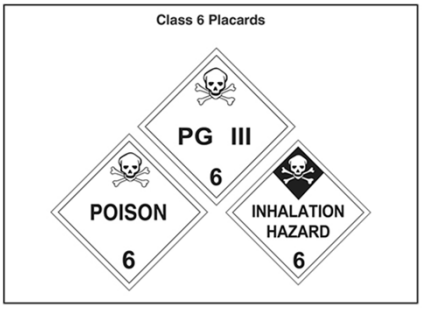
Table 4.9
Class 5 Divisions, Placards, Definitions, and Examples

Division Number and Placard	Definition
Division 5.1 	**Oxidizer** — Material that may, generally by yielding oxygen, cause or enhance the combustion of other material *Examples:* chromium nitrate; copper chlorate; calcium permanganate, ammonium nitrate fertilizer
Division 5.2  	**Organic Peroxide** — Any organic compound containing oxygen (O) in the bivalent -O-O- structure and which may be considered a derivative of hydrogen peroxide, where one or more of the hydrogen atoms has been replaced by organic radicals *Examples:* liquid organic peroxide type B

Source: 49 CFR 173.127 and 128

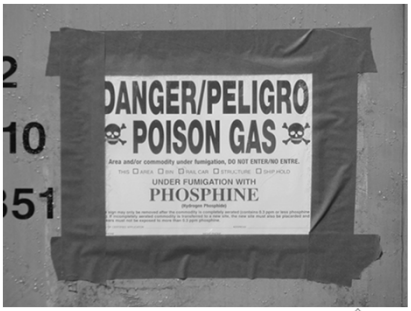
4–167

Class 6 includes Poisons, Poison Inhalation Hazards, and Infectious Substances.



4–168

Avoid contact with poisonous materials as they are toxic to humans.



4–169

Inhalation hazards are toxic vapors that can be lethal if inhaled.

4–170

Infectious substances and biohazards have the potential to cause disease in humans or animals.

Infectious materials are typically shipped in small containers, so there is no placard for them, only a label

A biohazard label is used for large and small quantities of regulated medical waste

Class 6 materials also have secondary hazards.

- Toxic hazards
- Thermal hazards (heat) from flammability and fires
- Chemical hazards from toxic and/or corrosive products of combustion
- Thermal hazards (heat) from substances transported in molten form

WARNING

Do not inhale or come into contact with the secondary hazards of Class 6 materials.

There are multiple Class 6 divisions and placards.

Table 4.10
Class 6 Divisions, Placards, Definitions, and Examples

Division Number and Placard	Definition
Division 6.1 	**Poisonous Material** — Material, other than a gas, that is known to be so toxic to humans as to afford a hazard to health during transportation or that is presumed to be toxic to humans based on toxicity tests on laboratory animals *Examples:* aniline, arsenic, liquid tetraethyl lead
	**PG III** — For Division 6.1, packing group III* (PG III) materials, a POISON placard may be modified to display the text "PG III" below the mid line of the placard rather than the word "POISON." **A packing group is a DOT packaging category based on the degree of danger presented by the hazardous material. Packing Group I indicates great danger; Packing Group II, medium danger; and Packing Group III, minor danger.The PG III placard, then, might be used for materials that are not as dangerous as those that would be placarded with the "POISON"placard.* *Examples:* chloroform, alkaloid solids
	**Inhalation Hazard Placard** — Used for any quantity of Division 6.1, Zones A or B inhalation hazard only (see Division 2.3 for hazard zones) *Examples:* nerve agents, cyanide

Source: 49 CFR 173.132 and 134

Class 6 has two unique placards.

Table 4.11
Class 6 Unique Labels, Definitions, and Examples

Division Number and Label	Definition
Division 6.2 	**Infectious Substance** — Material known to contain or suspected of containing a pathogen. A pathogen is a virus or microorganism (including its viruses, plasmids, or other genetic elements, if any) or a proteinaceous infectious particle (prion) that has the potential to cause disease in humans or animals. *Examples:* anthrax, hepatitis B virus, *escherichia coli* (e coli)
	**Biohazard Label** — Marks bulk packaging containing a regulated medical waste as defined in 49 CFR 173.134(a)(5). *Examples:* used needles/syringes, human blood or blood products, human tissue or anatomical waste, carcasses of animals intentionally infected with human pathogens for medical research

Class 7 encompasses radioactive materials.

Class 7 Placard

Radioactive materials cannot be detected with the senses.

Class 7 placards and labels can indicate that radioactive materials are present

Without specialized monitoring and detection equipment, it is not possible to determine if a container is actually emitting radiation

It is impossible to tell if radiation is involved in an incident, such as a terrorist attack, where no placards or labels are evident

4–177

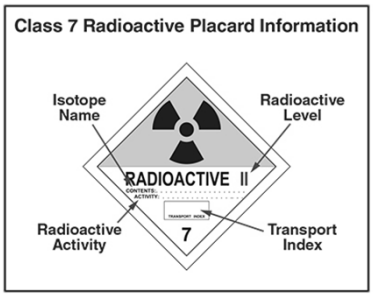
Small packages of radioactive materials must be labeled on two opposite sides.

Unique trefoil symbol for radiation

- RADIOACTIVE WHITE-I
- RADIOACTIVE YELLOW-II
- RADIOACTIVE YELLOW-III

4–178

Class 7 labels must provide the isotope name, activity level, transport index, and radioactive level.



4–179

Common industrial and medical isotope names might be seen on Class 7 labels.

Common Isotopes

Industrial	Medical
Cs-137	Tl-201
Co-60	Tc-99m
Ir-192	I-131
Am-241	I-125
	Pd-103
	Ru-106

4–180

NOTE

Items placarded as Radioactive II and III have a maximum allowed TI rating of 50 mrem/hr at 1 meter.

4–181

Table 4.12 provides Class 7 placards, definitions, and examples.

Table 4.12
Class 7 Divisions, Placards, Definitions, and Examples

Division Number and Label	Definition
Division 7 	**Radioactive Placard** — Is required on certain shipments of radioactive materials; vehicles with this placard are carrying "highway route controlled quantities" of radioactive materials and must follow prescribed, predetermined transportation routes *Examples:* solid thorium nitrate, uranium hexafluoride

Source: *49* CFR *173.403*

4–182

Table 4.13 provides Class 7 unique labels, definitions, and examples.

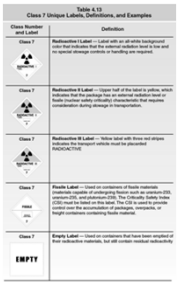
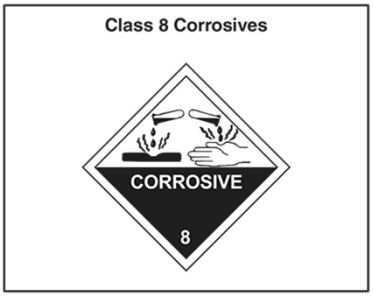


Table 4.13
Class 7 Unique Labels, Definitions, and Examples

Class Number and Label	Definition
Class 7	**Radioactive I Label** — Label with an all-white background color that indicates that the external radiation level is low and no special stowage controls or handling are required.
Class 7	**Radioactive II Label** — Upper half of the label is yellow, which indicates that the package contains a greater amount of radioactive material or fissile (nuclear safety criticality) characteristic that requires consideration during stowage in transportation.
Class 7	**Radioactive III Label** — Yellow label with three red stripes indicates the transport vehicle must be placarded RADIOACTIVE
Class 7	**Fissile Label** — Used on containers of fissile materials (materials capable of undergoing fission such as uranium-233, uranium-235, and plutonium-239). The Criticality Safety Index (CSI) must be listed on this label. The CSI is used to provide control over the accumulation of packages, overpacks, or freight containers containing fissile material.
Class 7	**Empty Label** — Used on containers that have been emptied of their radioactive materials, but still contain residual radioactivity. EMPTY

Class 8, Corrosives, are either a liquid or solid that can damage metal and skin.



Corrosives can be toxic, flammable, reactive, and/or explosive and some are oxidizers.

The primary hazards of Class 8 materials are chemical, toxic, thermal and mechanical.

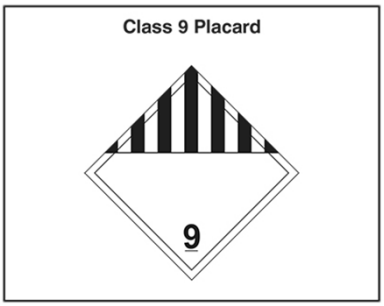
- Chemical hazards such as chemical burns
- Toxic hazards due to exposure via all routes of entry into a body
- Thermal hazards (heat), including fire, caused by chemical reactions generating heat
- Mechanical hazards caused by BLEVEs and violent chemical reactions

Table 4.14 provides Class 8 placards, definitions, and examples.

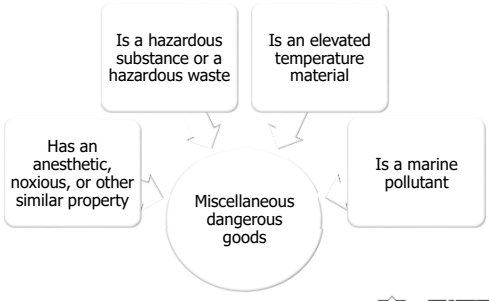
Table 4.14
Class 8 Division, Placard, Definition, and Examples

	**Corrosive Placard** A corrosive material means a liquid or solid that causes full thickness destruction of human skin at the site of contact within a specific period of time or a liquid that has a severe corrosion rate on steel or aluminum. *Examples:* battery fluid, chromic acid solution, soda lime, sulfuric acid, hydrochloric acid (muriatic acid), sodium hydroxide, potassium hydroxide

Class 9 is composed of miscellaneous hazardous materials.



Miscellaneous dangerous goods have varied properties.



Miscellaneous dangerous goods will primarily have thermal and chemical hazards.

- Elevated temperature materials may present some thermal hazards
- Polychlorinated biphenyls (PCBs) are carcinogenic
- Hazardous wastes may present any of the hazards associated with the materials in normal use

Table 4.15 provides Class 9 placards and examples.

Table 4.15
Class 9 Divisions, Placards, Definitions, and Examples

A miscellaneous dangerous good is a material that (1) has an anesthetic, noxious, or other similar property that could cause extreme annoyance or discomfort to flight crew members and would prevent their correct performance of assigned duties; (2) is a hazardous substance or a hazardous waste; or (3) is an elevated temperature material; or (4) is a marine pollutant.

Miscellaneous dangerous goods will primarily have thermal and chemical hazards. For example, polychlorinated biphenyls (PCBs) are carcinogenic, while elevated temperature materials may present some thermal hazards. However, hazardous wastes may present any of the hazards associated with the materials in normal use.

9	**Miscellaneous Placard** *Examples:* blue asbestos, polychlorinated biphenyls (PCBs), solid carbon dioxide (dry ice)
DANGEROUS	**Dangerous Placard** — A freight container, unit load device, transport vehicle, or railcar that contains nonbulk packaging with two or more DOT Chart 12, Table 2 categories of hazardous materials may be placarded *DANGEROUS*. However, when 2,205 lbs (1,000 kg) or more of one category of material is loaded at one loading facility, the placard specified in DOT Chart 12, Table 2 must be applied.

REVIEW QUESTION

List the hazard classes and give examples of each class that a first responder might commonly encounter.

Learning Objective 5

Describe actions taken to gather sufficient information to identify the hazardous material(s)/substance(s) involved in a hazmat incident.

Responders should contact additional resources that can provide additional technical information.

Use approved sources to gather information about a material's properties.

- *Emergency Response Guidebook* (*ERG*)
- Shippers and shipping papers
- Safety Data Sheets (SDS)
- Pipeline operators
- Computer apps such as CAMEO and Wiser
- Placards and labels
- Manufacturers

4–195

NOTE

Local, state, and governmental authorities may also provide assistance.

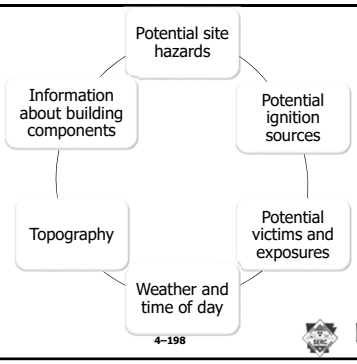
4–196

Sources may also include additional information.

- Potential health hazards
- Signs and symptoms of exposure
- Responsible party contact information
- Precautions for safe handling and control measures
- PPE and spill cleanup procedures
- Emergency and first aid procedures

4–197

First responders need to survey surrounding conditions.



4–198

Always survey surrounding conditions for hazards.

Courtesy of Rich Mahaney

4–199

The locations of hazmat incidents often have their own site hazards.

Courtesy of South Wales Fire Brigades

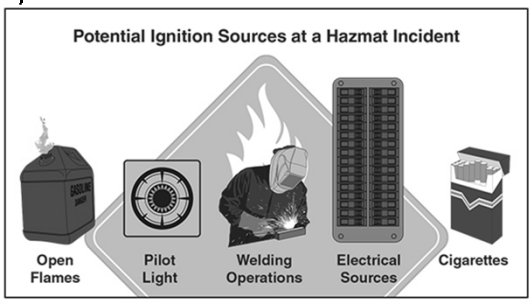
4–200

Responders must avoid igniting potential ignition sources.

Open flames	Static electricity	Pilot lights	Electrical sources including non-explosion-proof electrical equipment
Internal combustion engines in vehicles and generators	Heated surfaces	Cutting and welding operations	Radiant heat
Heat caused by friction or chemical reactions	Cigarettes and other smoking materials	Cameras/cellular phones	Road flares

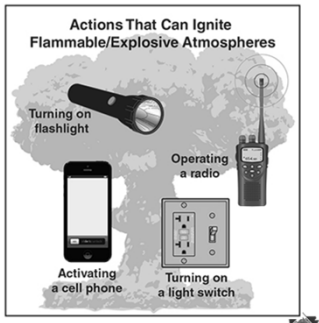
4–201

Many potential ignition sources may exist at the scene of a hazardous materials incident.



4–202

Avoid actions that can ignite flammable/explosive atmospheres.



4–203

Responders must quickly identify potential victims and exposures.

Potential exposures	• Include people, property, and the environment • Will determine the need for rescue and protective actions
Nature and extent of injuries may	• Give clues to the product(s) involved and hazards present • Determine the need for decontamination and medical care

4–204

Weather can dramatically affect how an outdoor incident progresses and is mitigated.

Temperatures below freezing	• May be impractical or impossible to use water for decontamination or dilution processes
Hot temperatures	• May cause liquids to evaporate more rapidly, producing more vapors or potentially raising a flammable material's temperature to its ignition point
Wind direction	• May determine where and how far gases, vapors, or solid particulates travel
Rain or high humidity	• May cause water-reactive materials to burn or explode

4–205

Time of day can influence chemical behavior and incident hazards.

At night
- Winds tend to be lighter
- Gases and vapors will not typically travel as far
- Tends to be cooler, so liquids tend not to evaporate as rapidly

Temperature gradients may be significantly different in an area due to topography and bodies of water

4–206

Topography is a factor in both rural and developed environments.

Topography affects the appropriate isolation distance

Topography may play an important role in where liquid and gaseous hazardous materials travel

4–207

Drainage areas may lead to environmentally sensitive areas that require protection.

Streams and rivers

Storm and sewer drains

Ponds, lakes, or wetlands

4–208

Topography may affect the potential movement of hazardous vapors and gases.

Local thermal winds

Mountain or valley elevation

Upslope winds

Aspect

Downslope winds

Breezes

4–209

Building information may affect hazards present an at and incident.

- Location of floor drains
- Air handling ducts, returns, and units
- Location and components of fire protection and detection equipment
- Location of gas, electric, and water shut-off locations
- Presence of potential backup generators

4–210

Emergency Response Centers

The *ERG* provides contact information for emergency response centers in

- U.S.
- Canada
- Mexico
- Argentina
- Brazil
- Colombia

4–211

Many manufacturers and shippers use CHEMTREC® and CANUTEC® as their emergency response contact numbers.

Courtesy of Rich Mahaney

4–212

NOTE

CENACOM has phone numbers dedicated to calls originating in Mexico City and its metropolitan area. Do not call these numbers if you are not in that area.

Before you contact the emergency response center, collect pertinent information.

- Caller's name, callback telephone number, and fax number
- Location and nature of problem (such as spill or fire)
- Name and identification number of material(s) involved
- Shipper/consignee/point of origin
- Carrier name, railcar reporting marks (letters and numbers), or truck number
- Container type and size
- Quantity of material transported/released
- Local conditions
- Injuries, exposures, current conditions involving spills, leaks, fires, explosions, and vapor clouds
- Local emergency services that have been notified

Know what the emergency response center will be able to do.

- Confirm that a chemical emergency exists
- Record details electronically and in written form
- Provide immediate technical assistance to the caller
- Contact the shipper of the material or other experts
- Provide the shipper/manufacturer with the caller's name and callback number

REVIEW QUESTION

What types of information do you need to collect at a hazmat incident?

Chapter 4: Analyzing the Incident: Identifying Potential Hazards Answers

Key Terms

1. **Gas** – Compressible substance, with no specific volume, that tends to assume the shape of a container. Molecules move about most rapidly in this state.
2. **Liquid** – Incompressible substance with a constant volume that assumes the shape of its container; molecules flow freely, but substantial cohesion prevents them from expanding as a gas would.
3. **Solid** – Substance that has a definite shape and size; the molecules of a solid generally have very little mobility.
4. **Compressed Gas** – Gas that, at normal temperature, exists solely as a gas when pressurized in a container, as opposed to a gas that becomes a liquid when stored under pressure.
5. **Liquefied Gas** – Confined gas that at normal temperatures exists in both liquid and gaseous states.
6. **Combustible Gas Detector** – Device that detects the presence and/or concentration of predefined combustible gases in a defined area. May require additional features to indicate the results to an operator.
7. **Micron** – Unit of length equal to one-millionth of a meter.
8. **Physical Properties** – Properties that do not involve a change in the chemical identity of the substance, but affect the physical behavior of the material inside and outside the container, which involves the change of the state of the material. Examples include boiling point, specific gravity, vapor density, and water solubility.
9. **Vapor Pressure** – The pressure at which a vapor is in equilibrium with its liquid phase for a given temperature; liquids that have a greater tendency to evaporate have higher vapor pressures for a given temperature.
10. **Boiling Point** – Temperature of a substance when the vapor pressure equals atmospheric pressure. At this temperature, the rate of evaporation exceeds the rate of condensation. At this point, more liquid is turning into gas than gas is turning back into a liquid.
11. **Boiling Liquid Expanding Vapor Explosion (BLEVE)** – Rapid vaporization of a liquid stored under pressure upon release to the atmosphere following major failure of its containing vessel. Failure is the result of over-pressurization caused by an external heat source, which causes the vessel to explode into two or more pieces when the temperature of the liquid is well above its boiling point at normal atmospheric pressure.
12. **Vapor Density** – Weight of pure vapor or gas compared to the weight of an equal volume of dry air at the same temperature and pressure. A vapor density less than one indicates a vapor lighter than air; a vapor density greater than one indicates a vapor heavier than air.
13. **Solubility** – Degree to which a solid, liquid, or gas dissolves in a solvent (usually water).
14. **Polar Solvent** — 1) A material in which the positive and negative charges are permanently separated, resulting in their ability to ionize in solution and create electrical conductivity. Examples include water, alcohol, esters, ketones, amines, and sulfuric acid. 2) Flammable liquids with an attraction for water.
15. **Miscibility** – Two or more liquids' capability to mix together.
16. **Immiscible** – Incapable of being mixed or blended with another substance.
17. **Specific Gravity** – Mass (weight) of a substance compared to the weight of an equal volume of water at a given temperature. A specific gravity less than one indicates a substance lighter than water; a specific gravity greater than one indicates a substance heavier than water.
18. **Persistence** – Length of time a chemical agent remains effective without dispersing.
19. **Dispersion** – Act or process of being spread widely.
20. **Viscosity** – Measure of a liquid's internal friction at a given temperature. This concept is informally expressed as thickness, stickiness, and ability to flow.
21. **Mercaptan** – A sulfur-containing organic compound often added to natural gas as an odorant. Natural gas is odorless; natural gas treated with mercaptan has a strong odor. *Also known as a* Thiol.
22. **Chemical Properties** –Relating to the way a substance is able to change into other substances. Chemical properties reflect the ability to burn, react, explode, or produce toxic substances hazardous to people or the environment.

23. **Flash Point** – Minimum temperature at which a liquid gives off enough vapors to form an ignitable mixture with air near the surface of the liquid.
24. **Fire Point** – Temperature at which a liquid fuel produces sufficient vapors to support combustion once the fuel is ignited. Fire point must exceed five seconds of burning duration during the test. The fire point is usually a few degrees above the flash point.
25. **Flammable Liquid** – Any liquid having a flash point below 100°F (37.8°C) and a vapor pressure not exceeding 40 psi absolute (276 kPa) {2.76 bar}, per NFPA.
26. **Combustible Liquid** – Liquid having a flash point at or above 100°F (37.8°C) and below 200°F (93.3°C), per NFPA.
27. **Nonflammable** – Incapable of combustion under normal circumstances; normally used when referring to liquids or gases.
28. **Autoignition Temperature** – The lowest temperature at which a combustible material ignites in air without a spark or flame. (NFPA 921)
29. **Ignition Temperature** – Minimum temperature to which a fuel (other than a liquid) in air must be heated in order to start self-sustained combustion independent of the heating source.
30. **Lower Flammable (Explosive) Limit (LFL)** – Lower limit at which a flammable gas or vapor will ignite and support combustion; below this limit the gas or vapor is too *lean* or *thin* to burn (too much oxygen and not enough gas, so lacks the proper quantity of fuel). *Also known as* Lower Explosive Limit (LEL).
31. **Upper Flammable Limit (UFL)** –Upper limit at which a flammable gas or vapor will ignite. Above this limit, the gas or vapor is too rich to burn (lacks the proper quantity of oxygen). *Also known as Upper Explosive Limit (UEL).*
32. **pH** – Measure of the acidity or alkalinity of a solution
33. **Acid** – Compound containing hydrogen that reacts with water to produce hydrogen ions; a proton donor; a liquid compound with a pH less than 7. Acidic chemicals are corrosive.
34. **Ion** –Atom that has lost or gained an electron, thus giving it a positive or negative charge.
35. **Base** – Any alkaline or caustic substance; corrosive water-soluble compound or substance containing group-forming hydroxide ions in water solution that reacts with an acid to form a salt.
36. **Dissociation (Chemical)** – Process of splitting a molecule or ionic compounds into smaller particles, especially if the process is reversible. *Opposite of* Recombination.
37. **Saponification** – Reaction between an alkaline and a fatty acid that produces soap.
38. **Basic Solution** – Solution that has a pH between 7 and 14.
39. **Reactivity** – Ability of a substance to chemically react with other materials, and the speed with which that reaction takes place.
40. **Reactive Material** – Substance capable of chemically reacting with other substances; for example, material that reacts violently when combined with air or water.
41. **Activation Energy** – Minimum energy that starts a chemical reaction when added to an atomic or molecular system.
42. **Strong Oxidizer** – Substance that readily gives off large quantities of oxygen, thereby stimulating combustion; produces a strong reaction by readily accepting electrons from a reducing agent (fuel).
43. **Reducing Agent** – Fuel that is being oxidized or burned during combustion. *Also known as* Reducer.
44. **Inhibitor** – Material that is added to products that easily polymerize in order to control or prevent an undesired reaction. *Also known as* Stabilizer.
45. **Nonionizing Radiation** – Series of energy waves composed of oscillating electric and magnetic fields traveling at the speed of light. Examples include ultraviolet radiation, visible light, infrared radiation, microwaves, radio waves, and extremely low frequency radiation.
46. **Ionizing Radiation** – Radiation that causes a chemical change in atoms by removing their electrons.
47. **Electron** –Subatomic particle with a physical mass and a negative electric charge.
48. **Photon** – Weightless packet of electromagnetic energy, such as X-rays or visible light.
49. **Radioactive Material (RAM)** – Material with an atomic nucleus that spontaneously decays or disintegrates, emitting radiation as particles or electromagnetic waves at a rate of greater than 0.002 microcuries per gram (Ci/g).

50. **Exposure** – (1) Contact with a hazardous material, causing biological damage, typically by swallowing, breathing, or touching (skin or eyes). Exposure may be short-term (acute exposure), of intermediate duration, or long-term (chronic exposure). (2) People, property, systems, or natural features that are or may be exposed to the harmful effects of a hazardous materials emergency.
51. **Dose** – Quantity of a chemical material ingested or absorbed through skin contact for purposes of measuring toxicity.
52. **Contamination** – Impurity resulting from mixture or contact with a foreign substance.
53. **Contaminant** – Foreign substance that compromises the purity of a given substance.
54. **Inverse Square Law** – Physical law that states that the amount of radiation present is inversely proportional to the square of the distance from the source of radiation.
55. **Toxicity** – Degree to which a substance (toxin or poison) can harm humans or animals. Ability of a substance to do harm within the body.
56. **Systemic Effect** – Damage spread through an entire system; opposite of a local effect, which is limited to a single location.
57. **Asphyxiant** – Any substance that prevents oxygen from combining in sufficient quantities with the blood or from being used by body tissues.
58. **Irritant** – Liquid or solid that, upon contact with fire or exposure to air, gives off dangerous or intensely irritating fumes. *Also known as* Irritating Material.
59. **Convulsant** – Poison that causes convulsions.
60. **Carcinogen** – Cancer-producing substance.
61. **Allergen** – Material that can cause an allergic reaction of the skin or respiratory system.
62. **Carbon Monoxide (CO)** – Colorless, odorless, dangerous gas (both toxic and flammable) formed by the incomplete combustion of carbon. It combines with hemoglobin more than 200 times faster than oxygen does, decreasing the blood's ability to carry oxygen.
63. **Hydrogen Cyanide (HCN)** – Colorless, toxic, and flammable liquid until it reaches 79° F (26° C). Above that temperature, it becomes a gas with a faint odor similar to bitter almonds; produced by the combustion of nitrogen-bearing substances.
64. **Carbon Dioxide (CO_2)** – Colorless, odorless, heavier than air gas that neither supports combustion nor burns; used in portable fire extinguishers as an extinguishing agent to extinguish Class B or C fires by smothering or displacing the oxygen. CO_2 is a waste product of aerobic metabolism.
65. **Infectious** – Transmittable; able to infect people.
66. **Pathogen –** Biological agent that causes disease or illness.
67. **Contagious** – Capable of transmission from one person to another through contact or close proximity.
68. **Infectious Substance** – Substance that is known, or reasonably expected, to contain pathogens.
69. **Explosive** –Any material or mixture that will undergo an extremely fast self-propagation reaction when subjected to some form of energy.
70. **Division Number –** Subset of a class within an explosives placard that assigns the product's level of explosion hazard.
71. **Compatibility Group Letter** – Indication on an explosives placard expressed as a letter that categorizes different types of explosive substances and articles for purposes of stowage and segregation.
72. **Binary Explosive** – A type of explosive device or material with two components that are explosive when combined but not separately.
73. **Vapor Explosion** – Occurrence when a hot liquid fuel transfers heat energy to a colder, more volatile liquid fuel. As the colder fuel vaporizes, pressure builds in a container and can create shockwaves of kinetic energy.
74. **Organic Peroxide** – Any of several organic derivatives of the inorganic compound hydrogen peroxide.
75. **Maximum Safe Storage Temperature (MSST)** - Temperature below which the product can be stored safely. This is usually 20-30 degrees cooler than the SADT temperature, but may be much cooler depending on the material.

76. **Self-Accelerating Decomposition Temperature (SADT)** – Lowest temperature at which product in a typical package will undergo a self-accelerating decomposition. The reaction can be violent, usually rupturing the package, dispersing original material, liquid and/or gaseous decomposition products considerable distances.
77. **Poison** – Any material, excluding gases, that when taken into the body is injurious to health.
78. **Inhalation Hazard –** Any material that may cause harm via inhalation.
79. **Isotope** – Atoms of a chemical element with the usual number of protons in the nucleus, but an unusual number of neutrons; has the same atomic number but a different atomic mass from normal chemical elements.

Hazardous Materials for First Responders Fifth Edition

Chapter 5 — Analyzing the Incident: Identifying Containers and Predicting Behavior

HAZARDOUS MATERIALS FOR FIRST RESPONDERS
FIFTH EDITION

IFSTA

Learning Objective 1

Describe methods of identifying potential outcomes.

5–1

First responders must identify potential outcomes at a hazmat incident.

- Determine present hazards
- Estimate potential harm
- Predict how incident may progress

5–2

The initial survey should answer several questions.

- Where is the incident scene in relation to population and environmental property exposures?
- How much time has elapsed sine the incident began?
- What resources are available?
- What are the hazardous material involved?
- What is the condition of the container?
- What hazards does the site present?
- How is the material likely to behave?
- What kind of container holds the material?
- What has already been done?

5–3

Information must be quickly synthesized to form a clear picture of an incident.

5–4

Responders must gather and correctly interpret information.

Size	• Is the endangered area changing or moving? • How wide should the initial isolation zone be?
Shape	• What is the shape of the endangered area?
Exposures	• Are people, animals, or property in the endangered area? • Is the environment in danger? • Are rescues needed?
Physical, health, and safety hazards	• What potential hazards do the material and its container present? • What other hazards are present? • What are the surrounding conditions?

5–5

Verify information when possible.

- Emergency response agencies
- Manufacturers
- Shippers
- Other resources

5–6

REVIEW QUESTION

What are some questions that should be asked to help you identify potential outcomes?

5–7

Learning Objective 2

Explain the role of the General Hazardous Materials Behavior Model in predicting the behavior of containers.

5–8

GEBMO can help a first responder understand how a hazardous material and its container are likely to behave.

GEBMO – General Emergency Behavior Model

=

General Hazardous Behavior Model

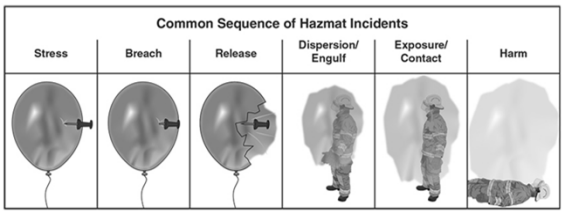
5–9

GEBMO assumes that hazmat incidents have three common elements.

- Material or materials presenting hazards to people, environment, or property
- Exposure or potential exposure to people, environment, or property
- Container or containers that have failed or have the potential to fail

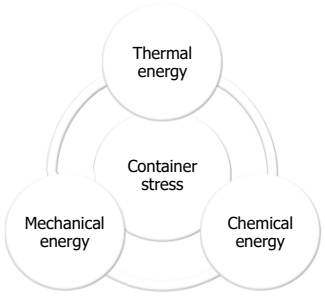
5–10

A common sequence usually occurs at hazmat incidents.



5–11

Container stress is caused by thermal, chemical, and mechanical energy.



5–12

Thermal stress may result from heating or cooling of the container.

A container undergoing excessive heat may be

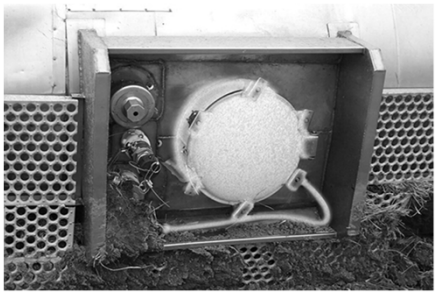
- Extremely close to flames
- Undergoing operation of a relief device
- Making noises of expansion or contraction
- Subject to changing environmental conditions

A container succumbing to cold may exhibit

- Excessive frosting
- Visible cold vapors (white clouds)
- Changes in steel structure (smooth to grainy)
- Pools of cold liquid

5–13

The appearance of frost is an indicator that a container is under thermal stress.



Courtesy of Barry Lindley

5–14

Chemical energy results from reactions/interactions of the container and contents.

Chemical reactions or interactions could result in	
	Sudden or long-term deterioration of the container
	Excess heat and/or pressure, causing container deterioration
	Corrosive or other incompatible interactions between the hazardous materials and the container material
	Visible corrosion or other degradation of container surfaces, including bulging, cracking, and/or popping noises
	No visible exterior indication even though the interior on the container may be under chemical stress

5–15

Chemical reactions may cause a container to bulge.

Courtesy of Barry Lindley

5–16

Mechanical energy results from physical application of energy.

Mechanical stress may	
	Change the shape of the container
	Reduce thickness of the container surface
	Crack or produce gouges
	Unfasten or disengage valves and piping
	Penetrate the container wall

5–17

Mechanical energy can crush or damage a container.

Courtesy of Phil Linder

5–18

Between 2006-2014, container failure accounted for nearly 41% of all reported hazmat incidents.

When evaluating container stress, consider

- Type of container
- Product in container
- Type and amount of stress
- Potential duration of stress

5–19

Preventing container failure may require reducing or eliminating factors placing stress on the container.

Stress factors may be

Readily visible, such as a collision or a fire impinging on a container surface

Not directly observable and must be predicted based on conditions or other indirect indicators

5–20

The material's state of matter will affect the stress experienced by containers.

Gas containers	• Inherently subject to stress • Heating or cooling may increase or reduce this stress • Containers may fail catastrophically and/or BLEVE
Liquid containers	• May fail when subjected to fires • May also transport materials that polymerize; uncontrolled polymerization may cause container failure
Solids containers	• Most likely damaged via mechanical stressors • Exceptions would include reactive materials from hazard classes

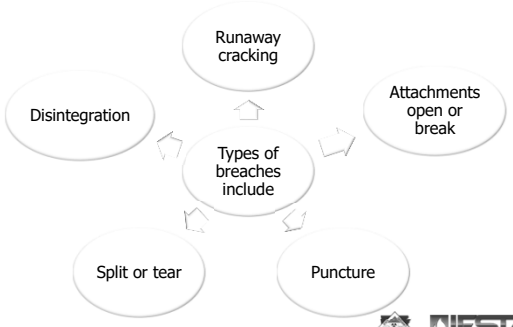
5–21

WARNING

Use extreme caution when working with containers that have been involved in an accident.

5–22

When a container is stressed beyond its limits of recovery, it opens or breaches and releases its contents.



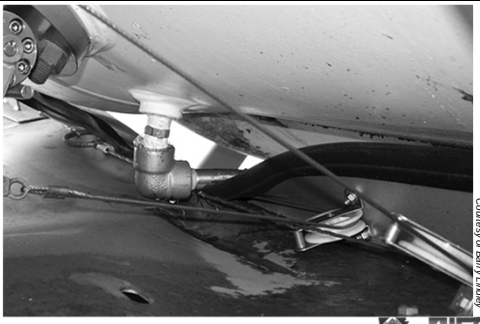
5–23

Runaway cracking breaks the container into two or more relatively large pieces or large tears.

Courtesy of Barry Lindley

5–24

Attachments (closures) may fail, open, or break off when subjected to stress, leading to a total failure of a container.



Courtesy of Barry Lindley

5–25

Puncture occurs when foreign objects penetrate through a container.

Courtesy of Barry Lindley

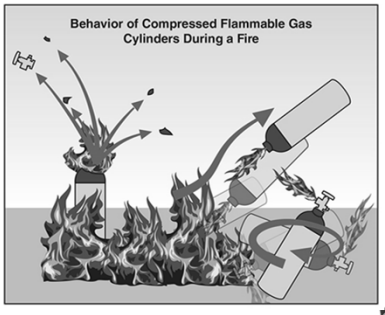
5–26

A split or tear may also cause a container to breach.

Courtesy of Rich Mahaney

5–27

When a container fails, its contents, energy, and the container itself (whole or in pieces) may release.



Cylinders of pressurized flammable gases can behave like erratic rockets if they suffer a release

5–28

Releases are classified according to how fast they occur.

Detonation	• Hundredths or thousandths of a second
Violent rupture	• One second or less
Rapid relief	• Several seconds to several minutes
Spill or leak	• Several minutes to several days

5–29

Detonation is the instantaneous and explosive release of chemical or mechanical energy.

Detonation

- Duration measured in hundredths or thousandths of a second
- Could result in fragmentation, disintegration, or shattering of the container; extreme overpressure; and considerable heat
- Example: explosion

5–30

Violent rupture is the immediate release of chemical or mechanical energy.

Violent rupture

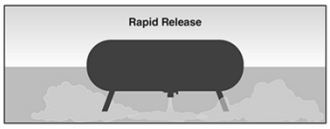
- Occurs within a timeframe of one second or less
- Results in ballistic behavior of the container and its contents and/or localized projection of container pieces/parts and hazardous material
- Example: BLEVE

5–31

Rapid relief is the fast release of a pressurized hazardous material through properly operating safety devices.

Rapid relief

- Occurs in a period of several seconds to several minutes
- Damaged valves, damaged piping, damaged attachments, or holes in the container can result in rapid relief



5–32

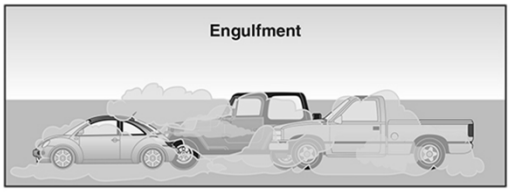
A spill or leak is the slow release of a hazardous material.

Spill or leak

- Slow release of a hazardous material under atmospheric or head pressure through holes, rips, tears, or usual openings/attachments
- Occur in a period lasting from several minutes to several days

5–33

The dispersion of a material is also referred to as engulfment.



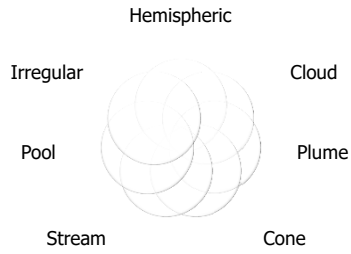
5–34

Dispersion of the hazardous material, energy, and container depends on the type of release.

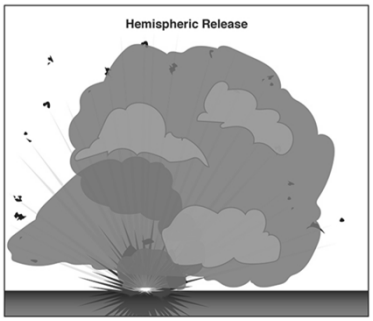
- Solid, liquid, gas/vapor
- Mechanical, thermal, or chemical energy and ionizing radiation
- Product characteristics and environmental conditions

5–35

The dispersion pattern describes the shape and size of the dispersing hazardous material.

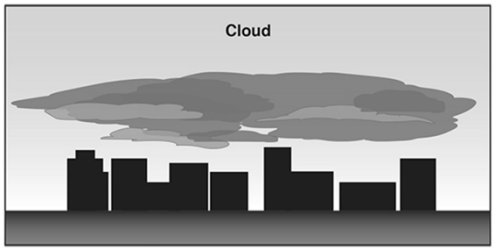


A hemispheric release is a semi-circular or dome-shaped pattern.



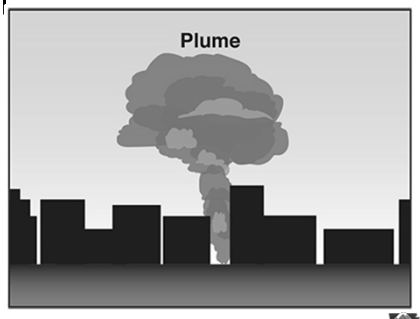
Airborne hazardous material that is still partially in contact with the ground or water and generally results from a rapid release of energy

A cloud release is a ball-shaped pattern of airborne hazardous material.



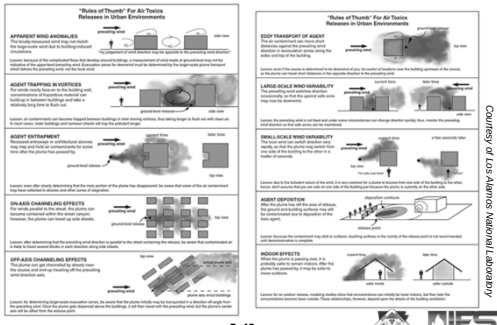
The material collectively rises above the ground or water; can disperse under minimal wind conditions

A plume release is an irregularly shaped pattern.



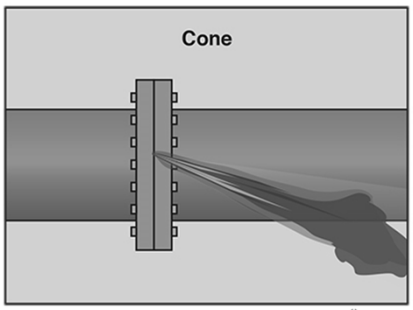
Airborne hazardous material influenced by wind and/or topography

Responders should be aware of these rules of thumb regarding plume modeling behavior in urban environments.

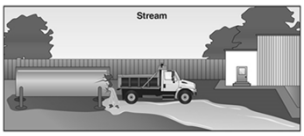


Courtesy of Los Alamos National Laboratory

A cone release is a triangular-shaped pattern with a point source at the breach and a wide base downrange.

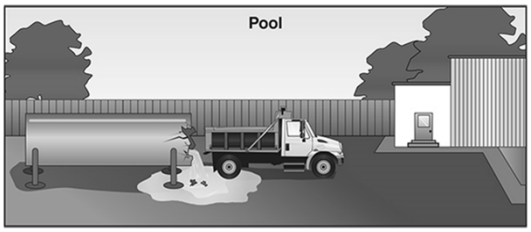


A stream release is pulled by gravity and follows the topography contours of the surface.



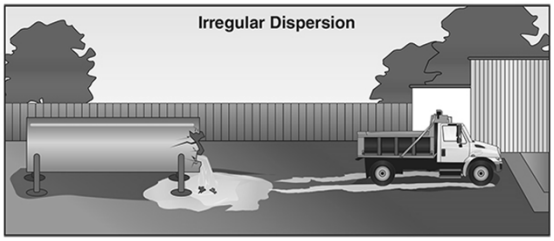
5–42

A pool release is when liquids assume the shape of their container, typically accumulating in low areas.



5–43

An irregular pattern results from indiscriminate deposit.



5–44

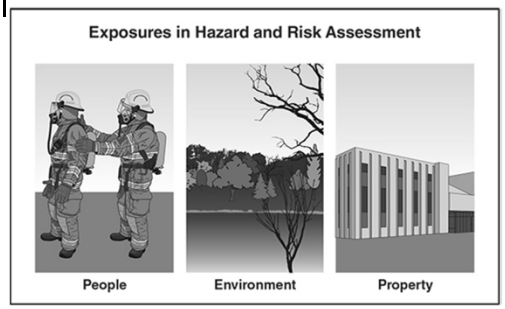
Computer software can assist in predicting plume dispersion patterns.

CAMEO

HPAC ALOHA

5–45

As a container releases, it may disperse its contents and the container itself on different types of exposures.



5–46

Contacts (impingements) are associated with general timeframes.

Immediate	• Milliseconds, seconds (deflagration, explosion, or detonation)
Short-term	• Minutes, hours (gas or vapor cloud)
Medium-term	• Days, weeks, months (lingering pesticide)
Long-term	• Years, generations (permanent radioactive source)

5–47

Harm is defined as injury or damage caused by exposure to a hazardous material.

Three mechanisms of harm in a hazardous materials incident

- Energy release
- Corrosivity
- Toxicity

REVIEW QUESTION

How does the General Hazardous Materials Behavior Model help predict hazards at hazmat incidents?

Learning Objective 3

Recognize general container types and their associated behaviors.

Some basic generalizations may be made about a hazmat incident based on the type(s) of container involved.

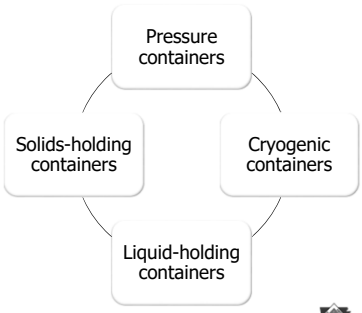


Table 5.1 provides an overview of four major types of containers and their relationship to aspects of the GEMBO.

Table 5.1
General Hazardous Materials Behavior Model by Container

State of Matter of Release	Pressure Containers	Cryogenic Containers	Liquid-Holding Containers	Solids-Holding Containers
Gas Release	Yes	Cold vapors that expand as they warm	Vapors from liquids that expand as vapor pressure and temperature	Reactive solids may release vapors/gases
Liquid Release	Cold liquid that rapidly expands into gas / vapor	Cold liquid that rapidly expands into gas	Yes	No
Solid Release	No	No	No	Yes
Common Stressors	**Pressure Containers**	**Cryogenic Containers**	**Liquid-Holding Containers**	**Solids-Holding Containers**
Thermal	High temperatures cause extreme stress	Contents are extremely cold and leaks may cause cold stress to contents or container supports	- High temperatures may cause extreme stress - Polymerization may cause heat build-up	High temperatures may cause extreme stress
Chemical	Corrosive materials may damage container components if released	May be highly oxidizing or flammable	- Corrosive materials may damage container components if released - Polymerization may occur	- Corrosive materials may damage container components if released - Decomposition may occur
Mechanical	Contents under high pressure - Accidents may cause mechanical damage	Accidents may cause mechanical damage	- Accidents may cause mechanical damage - Polymerization may cause pressure build-up	Accidents may cause mechanical damage
Common Breaches	**Pressure Containers**	**Cryogenic Containers**	**Liquid-Holding Containers**	**Solids-Holding Containers**
Disintegration*	Yes	Uncommon	Yes	Uncommon
"Runaway Cracking"	Yes	Uncommon	Yes	Uncommon
Weld/crevice	Yes	Yes	Yes	Yes
Puncture	Uncommon	No	Yes	Yes
Spills or leaks	Yes	Yes	Yes	Yes

* The higher the pressure of the container, the more likely a catastrophic failure will occur if the container is damaged.

Continued

Table 5.1 (concluded)

Common Releases	Pressure Containers	Cryogenic Containers	Liquid-Holding Containers	Solids-Holding Containers
Detonation	No	No	Liquid explosives	Explosive solids
Violent Rupture	Yes	Yes	Yes	Yes
Rapid Relief	Yes	Yes	Yes	Uncommon
Spill/Leak	Yes	Yes	Yes	Yes
Common Dispersion Patterns	**Pressure Containers**	**Cryogenic Containers**	**Liquid-Holding Containers**	**Solids-Holding Containers**
Hemispheric	Yes	Yes, if they Rupture	Yes	Yes (with explosives)
Cloud	Yes	Yes	Yes	Yes
Plume	Yes	Yes	Yes	No
Cone	Yes	Yes	Yes	Yes
Stream	Yes	No	Yes	No
Pool	Yes	Yes	Yes	No
Irregular	No	No	Yes	Yes

Common measurements for pressure include the psi, kPa, and bar.

Table 5.2
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

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Solid Release	No	No	No	Yes
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Disintegration*	Yes	Uncommon	Yes	Uncommon
Runaway Cracking*	Yes	Uncommon	Yes	Uncommon
Attachments	Yes	Yes	Yes	Yes
Punctures	Uncommon	No	Yes	Yes
Splits or tears	Yes	Yes	Yes	Yes

* The higher the pressure of the container, the more likely a catastrophic failure will occur if the container is damaged.

Continued

Table 5.1 (concluded)

Common Releases	Pressure Containers	Cryogenic Containers	Liquid-Holding Containers	Solids-Holding Containers
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Cloud	Yes	Yes	Yes	Yes
Plume	Yes	Yes	Yes	No
Cone	Yes	Yes	Yes	Yes
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Pool	Yes	Yes	Yes	No
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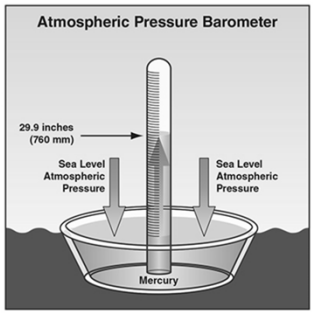
Nonpressure/Atmospheric Tanks	Up to 0.5 psi, 3.45 kPa, 0.03 bar

CAUTION

Approach each hazmat incident as a unique situation, regardless of commonalities between incidents.

5–54

Atmospheric pressure measures the force exerted by the weight of the atmosphere.



In this example, the greater the atmospheric pressure, the taller the column of mercury

5–55

Pressure at gauge describes a unit of pressure relative to the surrounding atmosphere.

Customary System	• pounds per square inch gauge (psig)
International System of Units (SI)	• kPaG
Metric (non-SI)	• bar

5–56

Pressure containers are subject to stress when carrying materials (gases or liquids).

Thermal stress	• Exposure to heat or flame can cause pressure containers to BLEVE
Chemical stress	• Released corrosive gases can cause additional damage to the container • Pressure on the container can increase by the reactions of the contents
Mechanical stress	• Accidents may cause mechanical stress, particularly to the container fittings • Severe accidents may cause damage to container walls

5–57

Pressure containers release rapidly expanding gases or liquids resulting in common dispersion patterns.

Hemispheric pattern — BLEVE

Cloud — A cloud above the container if there is little wind and the release is intermittent or short in duration

Plume — Depending on vapor density, terrain (particularly if vapor density is greater than 1), and wind speed

Cone — A steady release of product from a pressure container as it expands from the point of release outward

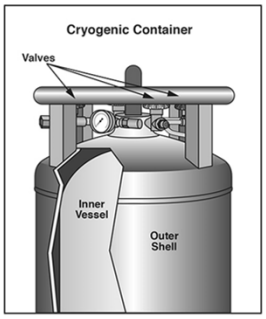
5–58

WARNING

Use extreme caution when handling pressure containers that have been involved in an accident.

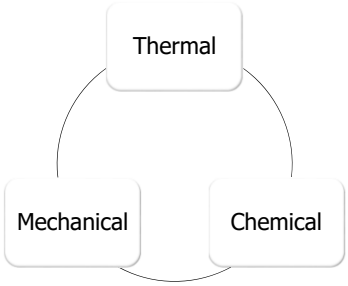
5–59

Cryogenic containers are durable containers that insulate their contents, keeping them cold.



5–60

Consider the common stressors of cryogenic containers.



5–61

NOTE

Venting is a function of some cryogenic containers and may not indicate a system failure.

5–62

Cryogenic containers can experience any type of breach.

Releases from pressure relief devices and/or damaged fittings are most common

Punctures, splits, and tears are rare, although violent accidents may involve enough force to damage both exterior and interior container walls

5–63

CAUTION

Cold stress and heat stress can result in similar failures.

5–64

Table 5.3 presents the expansion ratios of some common cryogenic materials.

Table 5.3
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

5–65

Table 5.3
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

The external support structure of a cryogenic container is NOT designed to withstand cold temperatures.

If cryogenic materials leak

→ The support structure can fail without warning

If other containers are involved in a wreck or derailment with cryogenic containers

→ Leaks from the cryogenic containers may cause failure of other containers due to cold stress

5–66

Cryogenic containers release cold liquids or vapors that rapidly boil into expanding gases.

Courtesy of Steve Irby, Owasso (OK) Fire Department

5–67

Cryogenic containers release their contents in typical dispersion patterns.

- Hemispheric
- Pool
- Cloud
- Plume

5–68

Liquid-holding containers come in a variety of designs and construction types.

Liquid containers may have following characteristics	Extremely durable, such as a tank car
	Fragile, such as a glass bottle
	May fail when subjected to fires
	Less likely to fragment as they BLEVE
	Transport materials that polymerize
	Uncontrolled polymerization (chemical stress) may create enough stress to cause container failure
	Explosive in nature

5–69

All dispersion patterns can be associated with liquids depending on the product and container.

Streams and pools are common dispersion patterns for liquids

Many liquids also release vapors that act like gases

5–70

Although solids-holding containers come in a variety of designs, most will be damaged by mechanical stressors.

Common breaches of solids-holding containers include

- Punctures
- Splits
- Tears

5–71

Solids typically release as spills or leaks.

Courtesy of Barry Lindley

5–72

Solids can also release in other ways.

Detonation	• Occurs when oxidizers, peroxides, explosives, and water-reactive materials are involved
Violent ruptures	• Reactive solids release
Clouds, cones, or via irregular dispersion	• Solids may disperse
Explosions	• Detonated explosives disperse in a hemispheric dispersion

5–73

REVIEW QUESTION

What are the major types of containers that hold hazardous materials?

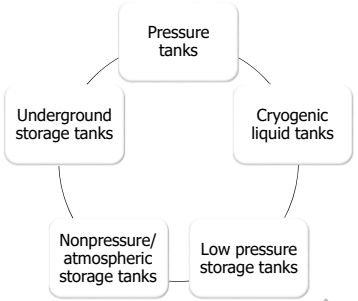
5–74

Learning Objective 4

Describe the types of bulk facility storage tanks and their associated hazards.

5–75

Bulk facility storage tanks come in several varieties.



5–76

Pressure tanks (also called *pressure containers* or *pressure vessels*) have pressures of 15 psi (103 kPa) or greater.

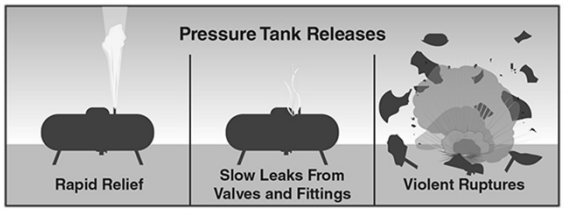
Table 5.4
Pressure Vessels

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 3 785 L). Once buried, the tank may be noticeable only because of a small access dome protruding a few inches (millimeters) above the ground.

5–77

Pressure tanks typically release their products as gases and vapors.



5–78

Pressure container failure incidents can be very dangerous.

Pressure tanks
- May contain a variety of flammable, toxic, and/ or corrosive gases.
- Can BLEVE when subjected to heating or fire

Contents leaking from these containers may expand rapidly and displace oxygen, especially in confined spaces

Flammable gases may travel far distances where they can ignite if exposed to an ignition source

Toxic gases may travel far distances and affect people and animals well away from the incident scene

5–79

Cryogenic liquid tanks may have pressures of 15 psi (103 kPa) or greater.

Courtesy of Rich Mahaney and Barry Lindley

Cryogenic tanks may contain cryogenic carbon dioxide, liquid oxygen, liquid nitrogen, or other products

5–80

NOTE

Some new Liquefied Natural Gas (LNG) tanks have a capacity of 30 to 60 million gallons (114 to 227 million L).

5–81

Materials released from bulk cryogenic liquid tanks will be very cold.

- Will tend to pool close to the ground
- Typically will initially be visible as a fog or cloud
- Most will displace oxygen
- Some will create an explosive environment

5–82

WARNING

Lack of visible indication does NOT mean that the hazard has dissipated.

Oxygen cryogenic (LOX) leaks on asphalt will make the asphalt shock-sensitive.

5–83

Low pressure storage tanks have operating pressures from 0.5 to 15 psi (3.45 kPa to 103 kPa).

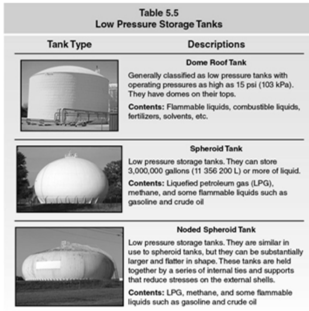


Table 5.5
Low Pressure Storage Tanks

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

Low pressure storage tanks typically contain flammable and combustible liquids with low vapor pressures.

- Associated hazards are flammability and/or toxicity
- Can release products as liquids or as gases and vapors
- Incident priority is eliminating ignition sources

Nonpressure/atmospheric storage tanks are designed to hold contents under little or no pressure.

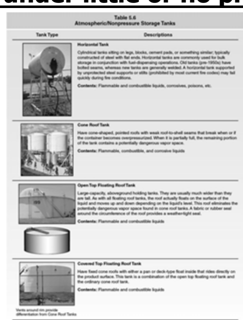


Table 5.6
Atmospheric/Nonpressure Storage Tanks

Tank Type	Descriptions
	Horizontal Tank Cylindrical tanks sitting on legs, blocks, cement pads, or something similar; typically constructed of steel with flat ends. Horizontal tanks are commonly used for bulk storage in conjunction with fuel-dispensing operations. Old tanks (pre-1950s) have bolted seams, whereas new tanks are generally welded. A horizontal tank supported by unprotected steel supports or stilts (prohibited by most current fire codes) may fail quickly during fire conditions. **Contents:** Flammable and combustible liquids, corrosives, poisons, etc.
	Cone Roof Tank Have cone-shaped, pointed roofs with weak roof-to-shell seams that break when or if the container becomes overpressurized. When it is partially full, the remaining portion of the tank contains a potentially dangerous vapor space. **Contents:** Flammable, combustible, and corrosive liquids
	Open Top Floating Roof Tank Large-capacity, aboveground holding tanks. They are usually much wider than they are tall. As with all floating roof tanks, the roof actually floats on the surface of the liquid and moves up and down depending on the liquid's level. This roof eliminates the potentially dangerous vapor space found in cone roof tanks. A fabric or rubber seal around the circumference of the roof provides a weather-tight seal. **Contents:** Flammable and combustible liquids
Vents around rim provide differentiation from Cone Roof Tanks	**Covered Top Floating Roof Tank** Have fixed cone roofs with either a pan or deck-type float inside that rides directly on the product surface. This tank is a combination of the open top floating roof tank and the ordinary cone roof tank. **Contents:** Flammable and combustible liquids

Continued

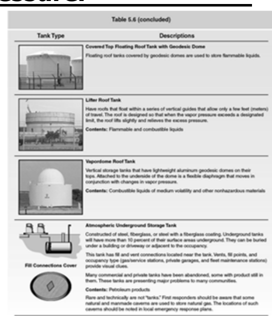


Table 5.6 (concluded)

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. This tank has fill and vent connections located near the tank. Vents, fill points, and occupancy type (gas/service stations, private garages, and fleet maintenance stations) provide visual clues. Many commercial and private tanks have been abandoned, some with product still in them. These tanks are presenting major problems to many communities. **Contents:** Petroleum products 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.

Nonpressure/atmospheric storage tanks typically hold liquids, most often hydrocarbons.

- May be flammable/combustible or corrosive and/or toxic
- Vapors may travel some distance from their liquid source
- Even when empty, these containers are likely to have dangerous atmospheres

Treat interiors of bulk nonpressure/ atmospheric storage tanks as confined spaces.

Underground storage tanks usually contain liquids.

Underground tanks are classified as low pressure or nonpressure/ atmospheric.

- Some horizontal propane pressure tanks have been buried underground
- More than ten percent of their surface areas are underground
- Can be buried under or adjacent to a building or driveway

5–90

Underground tanks have fill and vent connections located nearby.

5–91

Many commercial and private underground tanks have been abandoned.

Abandoned underground tanks may still contain product

Leaking underground storage tanks may go undetected until they leak

Fires and/or explosions can occur if flammable materials contact an ignition source

5–92

REVIEW QUESTION

List the types of bulk facility storage tanks and the hazards that they may present to first responders.

5–93

Learning Objective 5

Describe the types of cargo tank trucks and their associated hazards.

5–94

Cargo tanks transport hazardous materials via roads and highways.

Courtesy of Rich Mahaney

5–95

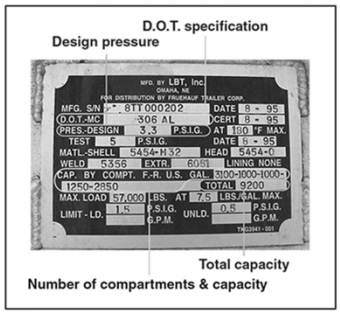
Cargo tank trucks are recognizable.

Even if first responders recognize one of the cargo tank trucks

Positive identification must proceed from placards to shipping papers or other formal sources of information

5–96

Cargo tank specification and name plates are usually found on the driver's side of the vehicle.



Courtesy of Rich Mahaney

Manufacturers' specification plates provide information about the tank's pressure, capacity, and number of compartments

5–97

The two specifications in use are the motor carrier (MC) standards and DOT/TC standards.

Cargo tank trucks built to a given specification are designated using the MC or DOT/TC initials

Followed by a three-digit number identifying the specification such as MC 306 and DOT/TC 406

5–98

Nonspec tanks are not constructed to meet one of the common MC or DOT/TC specifications.

Nonspec tanks may haul nonregulated hazardous materials if the tank was designed for a specific purpose and exempted from DOT/TC requirements

Examples of nonregulated hazards include

Molten sulphur	Asphalt	Milk

5–99

Nonhazardous materials may be transported in cargo tanks.

5–100

High pressure tank trucks transport liquefied gases, high vapor-pressure liquids, and highly hazardous materials.

- Also known as MC-331 (or equivalent) cargo tanks
- Pressures typically between 100 to 500 psi (690 to 3 448 kPa)
- Typical capacities between 3,000 to 11,000 gallons (11 356 to 41 640 L)
- Single, steel compartment

5–101

"Bobtail Tanks" are used for local delivery of liquefied petroleum gas and anhydrous ammonia.

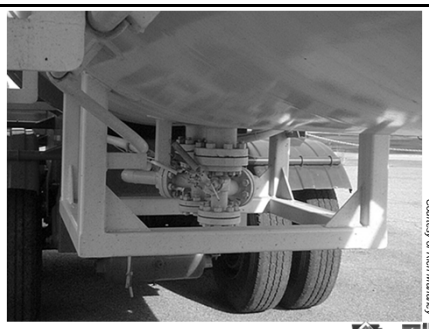
5–102

MC-331 cargo tank trucks are high pressure tank trucks.

- Bolted manway
- Inlet and outlet valves
- White or other reflective paint scheme (typically)
- Large hemispherical heads on both ends
- Guard cage around the bottom loading/unloading piping
- Uninsulated tanks, single-shell vessels
- Emergency shut-offs (typically located in the left front and right rear)
- Permanent markings

5–103

High pressure tank trucks have a cage guarding the bottom fittings.



Courtesy of Rich Mahaney

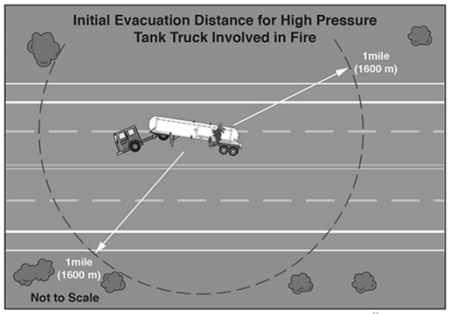
5–104

High pressure tank trucks have a variety of hazards.

- May experience disintegration, runaway cracking, damage to attachments, punctures, splits, or tears
- May release via violent rupture, rapid relief, or leaks
- May BLEVE
- Flammable gases/vapors may explode/ignite when coming into contact with an ignition source

5–105

The high pressure tank trucks involved in fire may BLEVE.



5–106

Cryogenic tank trucks are also known as MC-338, TC-338, or SCT-338 (or equivalent) cargo tanks.

- Pressures can be less than 25 and up to 500 psi (172 to 3 447 kPa)
- Capacities 8,000 to 10,000 gallons (30 283 to 37 854 L)
- Well-insulated aluminum or steel tanks with vacuum-sealed shells

5–107

Cryogenic tank trucks have a wide range of pressures.

5–108

Cryogenic tank trucks transport gases that have been liquefied by lowering their temperatures.

- Liquefied oxygen
- Liquefied hydrogen
- Liquefied nitrogen
- Liquefied carbon dioxide

5–109

When released, cryogens will be extremely cold.

- When released, product will be extremely cold
- Will tend to pool close to the ground
- Typically, the product will initially be visible as a fog or cloud
- As they warm, these liquids will change into gas state and expand

5–110

WARNING

Gases will displace oxygen when released.

Many released liquefied gases can kill a person with one breath due to oxygen deprivation leading to asphyxiation.

5–111

MC-338 tank trucks carry cryogenic materials.

- Relief valves
- Round tank with flat ends
- Large and bulky double shelling and heavy insulation
- Loading/unloading station
- Permanent markings
- Emergency shutoffs

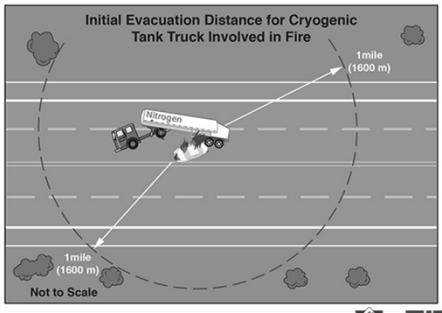
5–112

Cryogenic tank trucks may discharge nonhazardous vapors through their relief valves.

Courtesy of Rich Maharey

5–113

When exposed to heat or flames, cryogenic tanks may BLEVE.



5–114

Low pressure chemical tank trucks are also known as MC-307 or DOT/TC-407 (or equivalent) cargo tanks.

- Typically have a pressure of 25 to 35 psi (172 to 241 kPa)
- Typical capacities of 5,500 to 7,000 gallons (20 820 L to 26 500 L)
- Most have a stainless steel, mild steel, or aluminum tank
- May have a rubber lining, rubber coating, or polymer coating

5–115

Low pressure chemical tank trucks may carry flammable liquids, mild corrosives, and some toxics/poisons.

Courtesy of Rich Mahaney

5–116

Low pressure tank features can be recognized.

- Rounded or horseshoe-shaped ends
- Stiffening rings that may be visible or covered
- Rollover/turnover protection
- Single or multiple compartments
- Manway assembly protected by the rollover/turnover protection (crash box)
- Discharge piping at midship or rear
- Rear or middle unloading
- Pressure and vacuum protection
- Drain hose from the rollover/turnover protection down the side of the tank
- Emergency shutoffs (hydraulic or pneumatic) located on the left front of the tank

5–117

Stiffening rings are visible on this low pressure chemical tank truck.

Courtesy of Rich Mahaney

5–118

Typically, low pressure chemical tank trucks are involved in spills and leaks rather than violent ruptures.

Courtesy of Barry Lindley

5–119

Nonpressure cargo tank trucks are known as MC-306 or DOT/TC-406 (or equivalent) cargo tanks.

- New tanks constructed of aluminum or steel
- Older tanks made of steel
- Typical pressure is less than 4 psi (28 kPaG)
- Maximum capacity is 14,000 gallons (53 000 L) in U.S.
- Typical capacity range between 1,500 to 10,000 gallons (5 678 L to 37 854 L)

5–120

Nonpressure cargo tanks usually carry flammable and combustible liquids such as gasoline.

Courtesy of Rich Mahaney

5–121

MC-306 or DOT/TC-406 cargo tanks are recognizable.

- Oval shape
- Manways located in overturn protection areas
- Bottom valves
- Longitudinal rollover protection
- Valve assembly and unloading control box under tank
- Vapor-recovery system on curb side and rear, if present
- Multiple compartments
- Manway assemblies and vapor-recovery valves on top for each compartment
- Emergency shut-off systems

5–122

Nonpressure cargo tanks may have an unloading control box under the tank.

5–123

Nonpressure cargo tanks may be breached by splits, tears, and damage to attachments.

5–124

Corrosive liquid tank trucks are known as MC-312 or DOT/TC-412 (or equivalent) cargo tank trucks.

- Typical pressure range of 35 to 55 psi (241 kPa to 379 kPa)
- May have much higher maximum allowable working pressure (MAWP)
- Typical tank capacities 3,300 to 6,300 gallons (12 492 L to 23 848 L)
- Aluminum, mild steel, stainless steel, and fiberglass reinforced plastics (FRP) tanks can be rubber or polymer lined
- Outer jacket may be aluminum or stainless steel and often covers layer of insulation
- Usually only have one compartment

5–125

CAUTION

Liquid coming out of drain hoses may indicate leaks on the top of the tanks.

5–126

Corrosive liquid tank trucks carry corrosive liquids such as hydrochloric acid and sodium hydroxide.

5–127

MC-312 or DOT/TC-412 corrosive liquid tank trucks can be identified.

- Small-diameter round shape
- Exterior stiffening rings (may be visible on uninsulated tanks)
- Top unloading on the rear of the tank with exterior piping extending to the bottom of the tank
- Rollover protection around the valve assembly
- A pressure relief device (PRD) typically located in turnover protection
- Discolored loading/unloading area
- An area painted or coated with corrosive-resistant material

5–128

This corrosive liquid tank truck has an unloading area painted/coated in a different color.

5–129

WARNING

Most DOT/TC-412s do not have a shut-off valve.

5–130

Releases from corrosive liquid tank trucks may involve spilled/leaking liquids and vapors/fumes.

5–131

Compressed-gas/tube trailers transport individual steel cylinders stacked and mounted together.

- Typical pressures in tubes range from 2,400 to 5,000 psi (16 547 kPa to 34 474 kPa) (gas only)
- Each cylinder typically has overpressure device
- Carry helium, hydrogen, methane, oxygen, and other gases

5–132

Compressed-gas/tube trailers may be permanently parked at a facility.

5–133

Compressed-gas/tube trailers have typically recognizable features.

- Pressure relief device for each cylinder
- Bolted manway at front or rear
- Valves in a protected housing
- Valves manifolded together
- Permanent markings for the material or ownership that is locally identifiable

5–134

The numbers on this compressed-gas/tube trailer correspond to the pressure relief device for each cylinder.

Courtesy of Barry Lindley

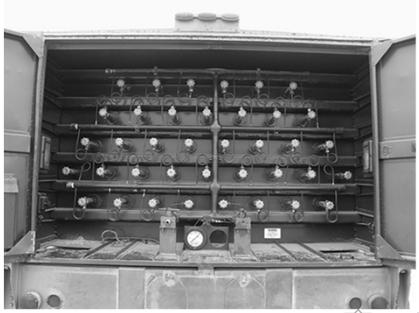
5–135

Compressed-gas/tube trailer cylinder valves are protected in a boxlike housing.

Courtesy of Rich Mahany

5–136

Compressed-gas/tube trailer cylinder valves are manifolded together.



5–137

Compressed-gas/tube trailers have multiple hazards.

- May experience disintegration, runaway cracking, damage to attachments, punctures, splits or tears
- May release via violent rupture, rapid relief, or leaks
- May BLEVE when exposed to heat or flames
- May explode/ignite when coming into contact with an ignition source
- Accidental releases from these trailers can be violent, and released gases will expand rapidly

5–138

Dry bulk cargo trailers transport solids.

- May transport hazardous solids such as oxidizers, corrosive solids, cement, plastic pellets, and fertilizers
  - Contents not usually under pressure
  - Low pressures between 15 to 20 psi (103 to 138 kPa) may be used to discharge or transfer product from container
  - Constructed to transport heavy loads
  - Damage to attachments, punctures, splits, or tears may occur if involved in accident

5–139

Dry bulk cargo trailers may transport oxidizers, corrosive solids, and other materials.

Courtesy of Rich Mahaney

5–140

Dry bulk cargo trailers have recognizable features.

- Varying shapes that often include bottom valves with *V-* or *W-*shaped bottom-unloading compartments
- Rear-mounted, auxiliary-engine-powered compressor or tractor-mounted power-take-off air compressor
- Air-assisted, exterior loading and bottom unloading pipes
- Top manway assemblies

5–141

Dry-bulk cargo trailers may have V- or W-shaped bottom-unloading compartments.

Courtesy of Rich Mahaney

5–142

Dry-bulk cargo trailers may have top manway assemblies.

Courtesy of Barry Lindley

5–143

REVIEW QUESTION

List the types of cargo tank trucks and the hazards that they may present to first responders.

5–144

Learning Objective 6

Describe the types of tank cars and their associated hazards.

5–145

Tank cars carry the bulk of the hazardous materials transported by rail.

Some railroad tank cars have capacities of 4,000 to 34,000 gallons (15 142 L to 128 704 L)

Because these cars carry large quantities, an accidental release of gases or liquids can cause many difficulties for responders

By recognizing distinctive railroad cars, first responders can begin the identification process from the greatest possible distance

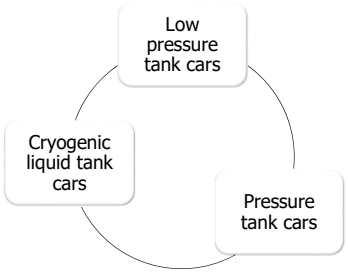
5–146

Railroad tank car capacities are much greater than cargo tank trucks.

Courtesy of Rich Mahaney

5–147

Tank cars are divided into three main categories.



5–148

Pressure tank cars typically transport flammable, nonflammable, and poisonous gases.

Courtesy of Rich Mahaney

5–149

Pressure tank cars can transport both gases and liquids.

- Pressure tank cars typically transport flammable, nonflammable, and poisonous gases
  - Pressures greater than 25 psi (172 kPa) at 68°F (20°C)
- Also transport flammable liquids and liquefied compressed gases
  - Pressures range from 100 to 600 psi (689 kPa to 4 137 kPa)
  - Capacities range from 4,000 to 34,000 gallons (15 142 L to 128 704 L)

5–150

NOTE

Though less common, some older jumbo cars can have a capacity of up to 50,000 gal (189 271L).

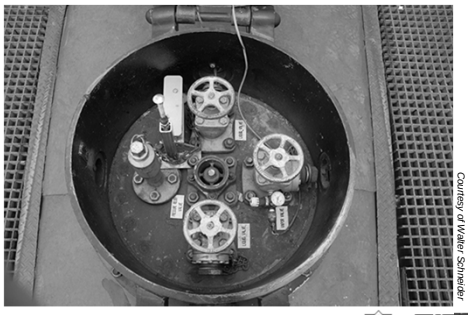
5–151

Pressure tank cars often have recognizable features.

- Cylindrical
- Noncompartmentalized
- Metal (steel or aluminum)
- Rounded ends (heads)
- Top-loading cars
- Out-of-sight fittings
- May be insulated and/or thermally protected

5–152

Pressure tank cars have fittings protected in a single housing on top of the tank.



Courtesy of Walter Schneider

5–153

Pressure tanks may have thermal insulation.

Courtesy of Barry Lindley

5–154

New pressure tank cars have greater accident protection features.

New pressure tank cars	Withstand greater damage without leaking	
	Thicker walls	
	Lower profile of protective housing	
	Higher tank test pressures	
	Significantly heavier than old cars	
	May also be equipped with	GPS tracking devices
		Anti-tampering mechanisms

5–155

Pressure tank cars may be equipped with GPS tracking devices.

Courtesy of Rich Mahaney

5–156

NOTE

Several highly hazardous liquids are shipped in pressure cars that have little to no vapor pressure.

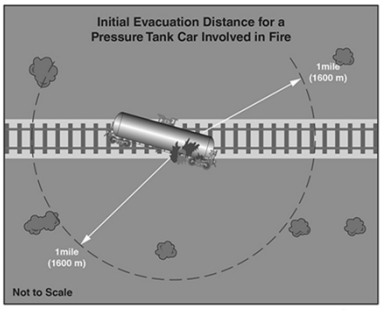
5–157

Pressure tanks have a variety of hazards.

- Subject to thermal, mechanical, and chemical damage
- Will release expanding gases or vapors
- Affected areas and evacuation zones may be quite large
- May BLEVE when exposed to heat or flame

5–158

The initial evacuation distance for a pressure tank car involved in fire is one mile (1 600 meters).



5–159

Cryogenic liquid tank cars carry low pressure refrigerated liquids.

- Pressure usually below 25 psi [172 kPa]
- Temperature -130°F and below (-90°C and below).
- Materials include argon, hydrogen, nitrogen, and oxygen
- Liquefied natural gas (LNG) and ethylene may be carried at somewhat higher pressures
- Often have fittings for loading/unloading, pressure relief, and venting

5–160

Cryogenic liquid tank cars may be recognized by ground-level cabinets on the side or end of the car.

Courtesy of Rich Mahaney

5–161

A cryogenic liquid tank car is a tank-within-a-tank.

- Stainless steel inner tank supported within a strong outer tank
- Space between the inner tank and outer tank is filled with insulation and kept under a vacuum
- Combination of insulation and vacuum protects contents from ambient temperatures for only 30 days - Shipper tracks shipments
- Per the *ERG*, the initial isolation zone for a cryogenic liquid tank car is ½ mile (1 km)

5–162

Low pressure tank cars transport solids and liquids.

5–163

Low pressure tank cars carry both hazardous and nonhazardous materials.

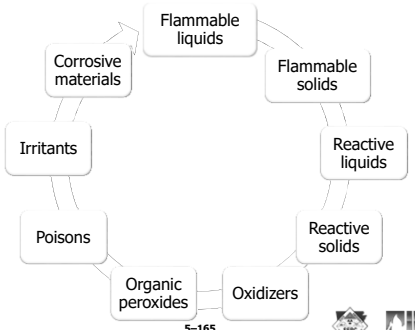
Vapor pressures below 25 psi (172 kPa) at 105°F to 115°F (41°C to 46°C)

Test pressures 60 and 100 psi (414 kPa and 689 kPa)

Capacities range from 4,000 to 34,000 gallons (15 142 L to 128 704 L) in newer tanks made of aluminum, mild steel, or stainless steel

5–164

Low pressure tank cars transport a variety of hazardous materials.



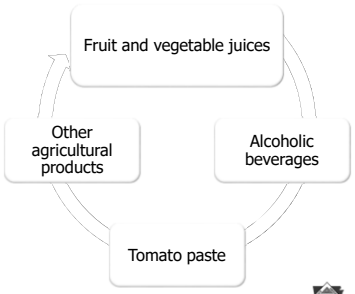
5–165

Oxidizers may be transported in low pressure tank cars.

Courtesy of Rich Mahaney

5–166

Low pressure tank cars also transport a variety of non hazardous materials.



5–167

Low pressure tank cars have recognizable features

- Cylindrical with rounded ends (heads)
- At least one manway for access to the tank's interior
- Compartmentalized with up to six compartments constructed as distinct tanks
- Fittings visible at the top and/or bottom of the car

5–168

This low pressure tank car has two tanks and each may carry separate products.

Courtesy of Rich Mahaney

5–169

Many low pressure tank cars have multiple fittings visible on the top and/or bottom of the car.

5–170

Low pressure DOT/TC 111 tank cars have fittings protected in a single housing, much like pressure tank cars.

Courtesy of Rich Mahaney

5–171

Check the specification markings to differentiate low pressure and nonpressure tank cars.

5–172

Trains transporting multiple low pressure tank cars containing Class 3 products may be HHFT.

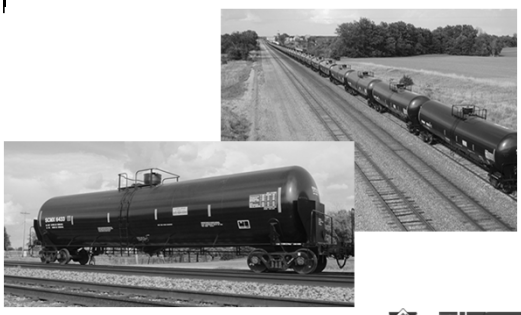
High-Hazard Flammable Trains (HHFT)

→ When involved in accidents, these tank cars can release their products

→ May ignite, and/or violently rupture

5–173

High-Hazard Flammable Trains (HHFT) often carry ethanol and crude oil.



Courtesy of Rich Mahaney

5–174

Responders may encounter new DOT/TC 117 tank cars.

Courtesy of Rich Mahaney

5–175

Covered hoppers carry solids, including oxidizers.

Courtesy of Rich Mahaney

5–176

Uncovered hoppers often carry coal.

Courtesy of Rich Mahaney

5–177

Pneumatically unloaded hopper cars transport solids.

Courtesy of Rich Mahaney

5–178

Boxcars carry a variety of mixed cargo, including packages of hazardous materials.

Courtesy of Barry Lindley

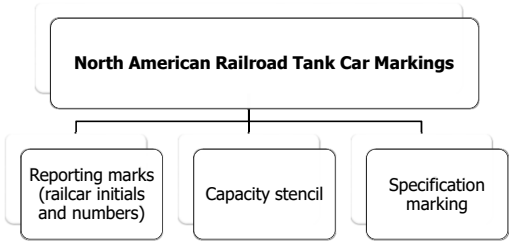
5–179

NOTE

Cars may be fumigated, presenting additional hazards.

5–180

North American railroad tank car markings provide valuable information.



5–181

Railcars are normally dedicated to transporting a single material.

- Dedicated tank cars may have name of material painted on the car
- DOT/TC only requires finite number of shipping names to be stenciled on car
- Some companies may include that information as a courtesy

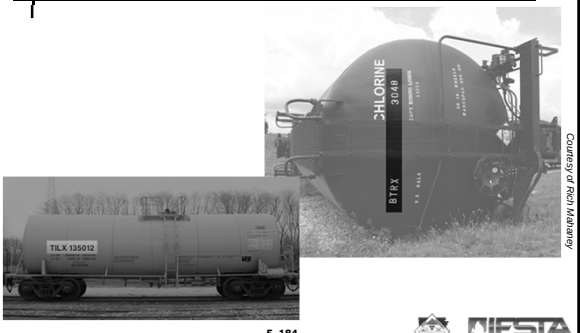
5–182

Tank cars are marked with their own unique sets of reporting marks.

Reporting marks	Also called *initials and numbers*
	May be used to obtain information about contents from railroad's computer, the shipper, CHEMTREC, CANUTEC, or SETIQ
	Should match the initials and numbers provided on the shipping papers
	Stenciled on both sides (to the left when facing the side of the car) and both ends (upper center) of the tank car tank
	Some shippers and car owners also stencil the top of the car with reporting marks

5–183

The reporting marks are highlighted on these tank cars.



Courtesy of Rich Hanney

5–184

The capacity stencil shows the volume of the tank car tank.

- Volume in gallons (and sometimes liters) stenciled on both ends of car under car's reporting marks
- Capacity in pounds (and sometimes kilograms) stenciled on sides of car under reporting marks
- *Load limit* may be used to mean the same thing as capacity in pounds or kilograms
- Water capacity (water weight) of tank, in pounds (and typically kilograms) stenciled on sides of tank near center

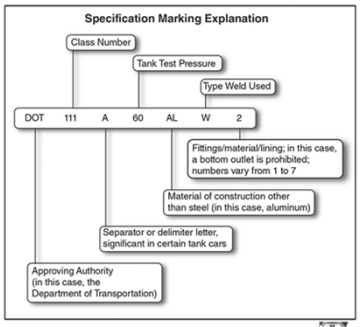
5–185

The load limit and capacity stencil are highlighted on this tank car.

Courtesy of Rich Mahaney

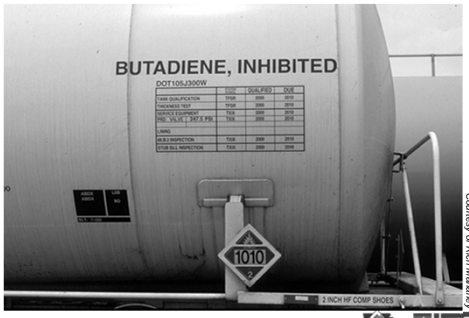
5–186

The specification marking indicates the standards to which a tank car was built.



5–187

Specification markings will be on the opposite end of the tank from the reporting marks.



Courtesy of Rich Mahaney

5–188

REVIEW QUESTION

List the types of tank cars and the hazards that they may present to first responders.

5–189

Learning Objective 7

Describe the types of intermodal tanks and their associated hazards.

5–190

Intermodal containers are used interchangeably in multiple modes of transport.

Freight containers	Tank containers
• Transport wide range of products, from foodstuffs to dry goods • Come in variety of types and sizes, most commonly in 20, 40, 45, 48, and 53 foot (6 m, 12 m, 14 m, 15 m, and 16 m) lengths	• Also called intermodal tanks • May contain hazardous materials in mixed packaging • May not be properly labeled

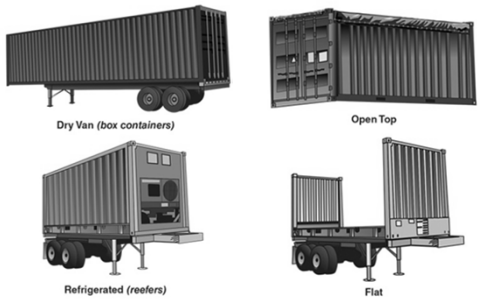
5–191

There are three general classifications of intermodal tank containers.

- Pressure intermodal tanks
- Low pressure intermodal tanks —also called nonpressure intermodal tanks
- Specialized intermodal tanks — such as cryogenic intermodal tanks and tube modules

5–192

There are several common types of intermodal freight containers.



5–193

Intermodal tank containers transport hazardous material worldwide.

Courtesy of Rich Mahaney

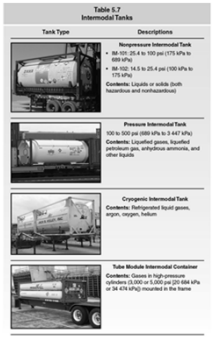
5–194

Intermodal freight containers may transport hazardous materials in a variety of packaging.

Courtesy of Barry Linsley

5–195

Intermodal tank containers generally have a cylinder enclosed at both ends.



First responders may also see tube modules, cryogenic tanks, compartmentalized tanks, or other shapes

5–196

The capacities of Intermodal tank containers ordinarily do not exceed 6,340 gallons (24 000 L).

Table 5.8
Intermodal Tank Container Descriptions

Specification	Materials Transported	Capacity	Design Pressure
IM 101 Portable Tank	Hazardous and nonhazardous materials, including toxics, corrosives, and flammables with flash points below 32°F (0°C)	Normally range from 5,000 to 6,300 gallons (18 927 L to 23 848 L)	25.4 to 100 psi (175 kPa to 689 kPa) (1.75 to 6.89 bar)
IM 102 Portable Tank	Whiskey, alcohols, some corrosives, pesticides, insecticides, resins, industrial solvents, and flammables with flash points ranging from 32°F to 140°F (0° to 60°C)	Normally range from 5,000 to 6,300 gallons (18 927 L to 23 848 L)	14.5 to 25.4 psi (100 kPa to 175 kPa) (1 to 1.75 bar)
Spec. 51 Portable Tank	Liquefied gases such as LPG, anhydrous ammonia, high vapor pressure flammable liquids, pyrophoric liquids (such as aluminum alkyls), and other highly regulated materials	Normally range from 4,500 to 5,500 gallons (17 034 L to 0 820 L)	100 to 500 psi (689 kPa to 3 447 kPa) (6.89 to 34.5 bar)

5–197

CAUTION

Intermodal freight containers can contain almost anything.

5–198

New intermodal container specifications include "T" Codes.

Courtesy of Barry Lindley

5–199

Pressure intermodal tanks are known as Spec. 51 or IMO Type 5 tanks.

Courtesy of Rich Mahaney

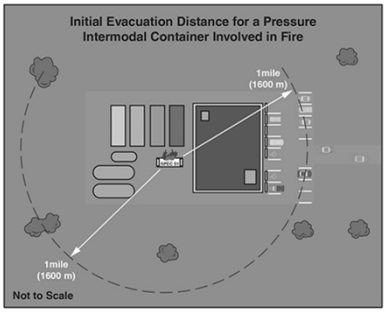
5–200

A pressure intermodal tank container is less common in transport.

- Designed for MAWPs of 100 to 500 psi (689 kPa to 3 447 kPa)
- Usually transports liquefied gases under pressure
- May be damaged during transport, loading, and unloading
- Leaks frequently involve the fittings, with the release of rapidly expanding gases or vapors
- May BLEVE if exposed to heat or flames

5–201

The potential for BLEVE requires a large initial evacuation distance.



5–202

Low pressure intermodal tanks are the most common intermodal tank used in transportation.

- May have pressures as high as 100 psi (689 kPa)
- Also called *intermodal portable tanks* or *IM portable tanks*
- Two common groups: IM 101 portable tanks and IM 102 portable tanks
- May be damaged during transport, loading, and unloading, including damage to fittings and container walls
- Releases commonly in the form of spilled liquids, often flammable or combustible

5–203

IM 101 portable tanks transport hazardous and nonhazardous liquids and solids.

Courtesy of Rich Mahaney

Built to withstand maximum allowable working pressures (MAWP) of 25.4 to 100 psi (175 kPa to 689 kPa)

5–204

IM 102 portable tanks are gradually being removed from service.

- Designed to handle maximum allowable working pressures (MAWP) of 14.5 to 25.4 psi (100 kPa to 175 kPa)
- Transport materials such as alcohols, pesticides, resins, industrial solvents, and flammables
- Flashpoints between 32°F and 140°F (0°C to 60°C)
- Most commonly transport nonregulated materials

5–205

Low pressure intermodal tanks present various hazards.

May be damaged during transport, loading, and unloading, including damage to fittings and container walls

Releases are commonly in the form of spilled liquids, often flammable or combustible

5–206

There are several types of specialized intermodal tank containers.

Cryogenic type containers

- Built to IMO Type 7 specifications
- Tube module transports gases in high-pressure cylinders
- MAWPs of 2,400 to 5,000 psi (16 547 kPa to 34 474 kPa)
- Carry refrigerated liquid gases, argon, oxygen, and helium

Dry bulk intermodal containers

- Carry materials such as fertilizer, cement, and plastic pellets

5–207

IMO Type 7 intermodals transport cryogenic materials.

Courtesy of Rich Mahaney

5–208

Dry bulk intermodals carry solids.

Courtesy of Rich Mahaney

5–209

Identifying markings on intermodal tanks and containers include reporting marks.

Generally found on right-hand side of container as you face it from either the sides or the ends

Use this information in conjunction with shipping papers or computer data to identify and verify contents

5–210

Reporting marks are required on intermodal containers.

Courtesy of Fitch Mahaney

5–211

Intermodal specification information identifies this as an IM 101 tank.

5–212

CAUTION

Read the intermodal container markings and understand all of the information provided.

5–213

REVIEW QUESTION

List the types of intermodal tanks and the hazards that they may present to first responders.

5–214

Learning Objective 8

Describe the types of bulk transportation containers and their associated hazards.

5–215

Some freight shippers and facilities use especially large capacity containers for bulk transportation and storage.

Ton containers

Y cylinders/
Y ton containers

5–216

Ton containers are pressure tanks.

- Capacities of 1 short ton or approximately 2,000 pounds (907 kg or 0.91 tonnes)
- Ends (heads) of containers are convex or concave
- Two valves in the center of one end, one above the other
- May have pressure-relief devices or fusible plugs

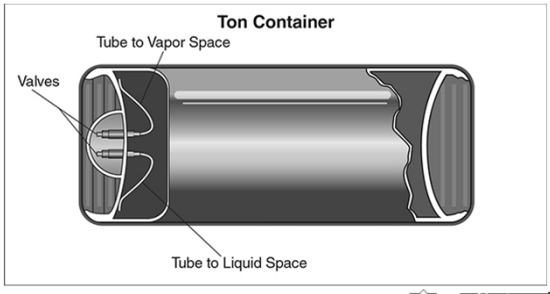
5–217

Ton containers are typically stored on their sides.

Courtesy of Rich Mahaney

5–218

Ton containers have one valve connected to the vapor space and one valve connected to the liquid space.



5–219

Ton containers may hold a variety of products and hazards.

- Chlorine ton containers often found at locations such as water treatment plants and commercial swimming pools
- May also contain products such as sulfur dioxide, anhydrous ammonia, or Freon® refrigerant
- Typically release their contents as gases or vapors
- Always evacuate responders and civilians to a safe distance to avoid vapor cloud
- Products often highly toxic and/or corrosive
- Evaluate available PPE for effectiveness during incidents involving these containers

5–220

Incidents involving ton containers typically require chemical protective clothing.

5–221

WARNING

Structural fire fighting gear does not provide adequate protection against the hazardous materials commonly stored in ton containers.

Y cylinders are a type of compressed gas cylinder that can be bulk or nonbulk.

Courtesy of Rich Mahaney

Y cylinders are typically classified as bulk.

A typical Y ton container	Will have a specification such as DOT/TC 3AA-2400 or DOT/TC 3AA-480
	Typically 7 feet (2 m) long
	2 ft (0.6 m) in diameter
	Wall thickness of about 0.6 inches (15 mm)
	When empty, weigh about 1,200 lbs (544 kg)
	Water capacity of approximately 120 gallons (454 liters), or 16 cubic feet (0.5 m^3)
	Often used for refrigerants, they typically operate in a cascade system

Y cylinders/Y ton containers have two specifications depending on size.

DOT/TC–3AA
- Seamless steel cylinder
- Water capacity (nominal) of not over 1,000 lbs (454 kg)
- Service pressure of at least 150 psig (1 034 kPaG)

DOT/TC–3AAX
- Seamless steel cylinder
- Water capacity of not less than 1,000 lbs (454 kg)
- Service pressure of at least 500 psig (3 447 kPaG)

REVIEW QUESTION

What is the difference between ton containers and Y Cylinder/Y Ton Containers?

Learning Objective 9

Describe the other types of bulk and nonbulk containers and their associated hazards.

Other bulk and nonbulk containers may be encountered.

- Pipelines
- Intermediate bulk containers
- Radioactive materials containers
- Nonbulk containers

5–228

All shipments of radioactive materials must be packaged and transported according to strict regulations.

Regulations protect public, transportation workers, and environment from potential exposure to radiation

Type of packaging used to transport radioactive materials determined by the activity, type, and form of material to be shipped

5–229

Radioactive material is shipped in one of five basic types of container.

Excepted	• Used to transport materials that have limited radioactivity
Industrial	• Retains and protects its contents during normal transportation activities
Type A	• Protects its contents and maintains sufficient shielding under conditions normally encountered during transportation
Type B	• Must also withstand severe accident conditions without releasing their contents
Type C	• Used for high-activity materials

5–230

Excepted packaging is used to transport materials that have limited radioactivity.

- Only used to transport materials with low levels of radioactivity that present no risk to the public or environment
- Examples: items manufactured from natural or depleted uranium or natural thorium and empty packaging
- Not marked or labeled - because of its low risk, exempt from several labeling and documentation requirements

5–231

Industrial packaging retains and protects contents during normal transportation activities.

- Contain materials that present a limited hazard to the public and the environment
- Examples include slightly contaminated clothing, laboratory samples, smoke detectors
- Not identified as such on the packages or shipping papers

5–232

Type A packaging protects and maintains sufficient shielding under transportation conditions.

- Must demonstrate ability to withstand series of tests without releasing contents
- Materials with relatively high specific activity levels — Examples include radiopharmaceuticals and certain regulatory qualified industrial products
- Package and shipping papers will have *Type A* on them

5–233

Type B packaging must demonstrate ability to withstand tests and severe accident conditions.

- Provides shielding against radiation
- Examples include materials that would present radiation hazard to public or environment if a major release, and materials with high levels radioactivity such as spent fuel from nuclear power plants
- Type B packages identified as such on package and shipping papers; sizes range from small containers to over 100 tons (91 tonnes)

5–234

Type C packaging is used for high-activity materials transported by aircraft.

- Designed to withstand severe accident conditions associated with air transport without loss of containment or significant increase in external radiation levels
- Performance requirements are significantly more stringent than those for Type B packages

5–235

Pipelines transport a variety of flammable and nonflammable hazardous gases and liquids.

Materials transported by pipelines include
Natural gas
Propane
Hydrogen
Crude oil
Diesel
Gasoline
Jet fuel
Home heating oils
Carbon dioxide
Anhydrous ammonia

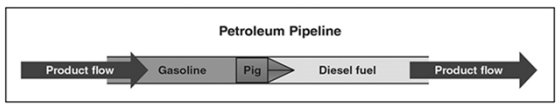
5–236

Pipelines are usually buried, but they may also be located aboveground.

- Pipelines come in variety of sizes and pressures depending on product and function of line
- Multiple products may be pushed through same pipeline at same time, or separated by pipeline pig
- Hydrocarbons are often comingled

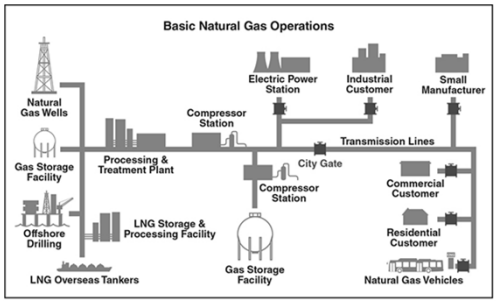
5–237

A single pipeline may carry more than one type of product, separated by a pipeline pig.



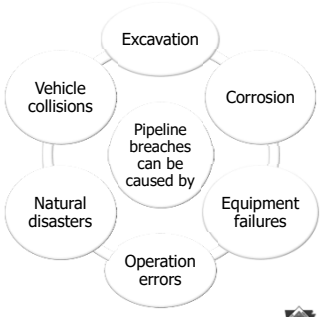
5–238

Pipeline operations are complex.



5–239

Pipeline breaches can be caused by multiple factors.



5–240

Pipeline incidents may involve many hazards.

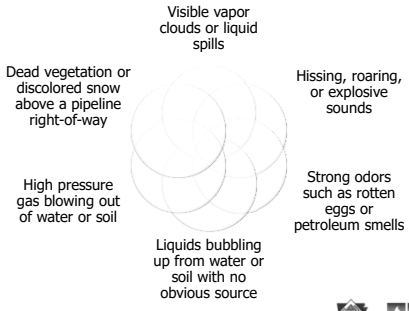
Pipeline releases can be violent, particularly if gases and/or high pressure transmission lines are involved

Spills and leaks can involve large quantities of product

Most products transported by pipelines are flammable or combustible, fire control should always be a priority consideration

5–241

Know the indicators of pipeline leaks or ruptures.



5–242

Pipeline markers in the U.S. and Canada contain useful information.

Include signal words *Caution*, *Warning*, or *Danger*, representing an increasing level of hazard

Contain information describing transported commodity, carrier's (operator's) name, emergency telephone number

5–243

Establish good communication and cooperation with pipeline operators *before* an emergency occurs.

Pipeline operators are required to provide a wealth of information to emergency responders that can help reduce the impact of an actual release, including

- Location of transmission pipelines that cross their area
- Name of the pipeline operator and emergency contact information
- Products carried and their hazards
- Location of pipeline emergency response plans
- How to contact the pipeline operator regarding questions, concerns, or emergencies
- How to safely respond to a pipeline emergency

5–244

NOTE

General considerations for responding to a pipeline emergency are provided on pages 23-25 of the 2016 *Emergency Response Guidebook*.

5–245

Facilities may also have piping carrying various materials.

Many industrial, commercial, and institutional facilities have piping carrying everything from water and steam to hazardous materials

Pipes carrying hazardous materials should be appropriately marked and labeled

Many facilities in U.S. and Canada follow ANSI's A13.1-1981, *Scheme for Identification of Piping Systems*, to mark and label pipes

5–246

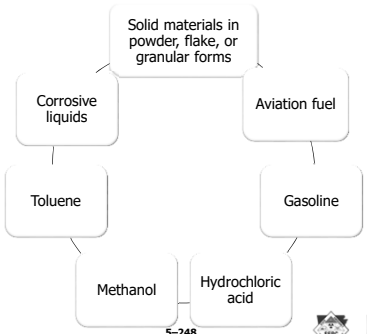
Intermediate bulk containers (IBC) are either rigid or flexible portable packaging designed for mechanical handling.

Design standards U.S., Canada, and Mexico based on United Nations Recommendations on the Transportation of Dangerous Goods

- Maximum capacity of an IBC is not more than 3 m^3 (3,000 L, 793 gal, or 106 ft^3)
- Minimum capacity is not less than 0.45 m^3 (450 L, 119 gal, or 15.9 ft^3) or a maximum net mass of not less than 400 kilograms (882 lbs)

5–247

IBCs are authorized to transport a wide variety of materials and hazard classes.



5–248

Both types of IBCs are often called *totes.*

FIBCs — Flexible intermediate bulk containers

RIBCs — Rigid intermediate bulk containers

5–249

FIBCs are flexible, collapsible bags or sacks.

- Sometimes called *bulk bags*, *bulk sacks*, *supersacks*, *big bags*, or *tote bags*
- Carry both solids and fluids
- Designs and sizes vary
- Some can be stacked
- Sometimes FIBCs are transported inside a rigid exterior container

5–250

A single flexible intermediate bulk container may carry the equivalent of four to five 55-gallon (200 liter) drums.

Courtesy of Rich Mahaney

5–251

RIBCs are made of rigid materials.

- Typically made of steel, aluminum, wood, fiberboard, or plastic
- Often designed to be stacked
- Can contain both solids and liquids
- Designs and sizes vary

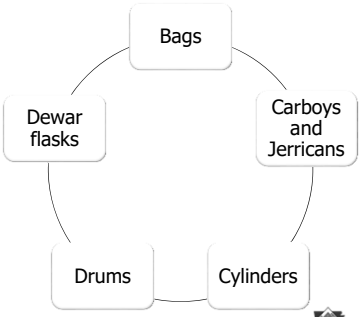
5–252

RIBCs may be square or rectangular boxes or bins designed to stack.

Courtesy of Rich Mahaney

5–253

Nonbulk packaging containers are used to transport smaller quantities of hazardous materials.



5–254

A bag is a flexible packaging.

Bags

- Made of paper, plastic, film, textiles, woven material, or others
- Sizes vary

Contents: Explosives, flammable solids, oxidizers, organic peroxides, fertilizers, pesticides, and other regulated materials.

5–255

Carboys and jerricans carry liquids.

5–256

A cylinder is a pressure vessel designed for pressures higher than 40 psi (276 kPa).

Cylinders

- Presssures higher than 40 psi (276 kPa) {2.76 bar} but vary
- Sizes range from lecture bottle size to very large

Contents: Compressed gases.

5–257

A drum is a flat-ended or convex-ended cylindrical packaging.

Drums

- Made of metal, fiberboard, plastic, plywood, or other materials
- May have open heads (removable tops) or tight (closed) heads with small openings
- Sizes vary from 55 gallons (208 L) to 100 gallons (379 L)

Contents: Hazardous and nonhazardous liquids and solids.

5–258

A dewar flask is a nonpressurized, insulated container with a vacuum space.

Dewar Flasks

- Vacuum insulated
- Made of glass, metal, or plastic with hollow walls from which the air has been removed
- Sizes vary

Contents: Cryogenic liquids; thermoses may contain nonhazardous liquids.

5–259

REVIEW QUESTION

List other types of containers that first responders may encounter and what kinds of hazardous materials they may carry.

5–260

Chapter 5: Analyzing the Incident: Predicting the Behavior and Identifying Containers Answers

Key Terms

1. **Size-Up** – Ongoing evaluation of influential factors at the scene of an incident.
2. **General Emergency Behavior Model (GEBMO)** – Model used to describe how hazardous materials are accidentally released from their containers and how they behave after the release.
3. **Limits of Recovery** – A container's design strength or ability to hold contents at pressure.
4. **Breach** – To make an opening in a structural obstacle (such as a masonry wall) without compromising the overall integrity of the wall to allow access into or out of a structure for rescue, hoseline operations, ventilation, or to perform other functions.
5. **Head Pressure** – Pressure exerted by a stationary column of water, directly proportional to the height of the column.
6. **Engulfment** – Dispersion of material as defined in the General Emergency Behavior Model (GEBMO); an engulfing event occurs when matter and/or energy disperses and forms a danger zone.
7. **Hemispheric Release** – Semicircular or dome-shaped pattern of airborne hazardous material that is still partially in contact with the ground or water.
8. **Cloud –** Ball-shaped pattern of an airborne hazardous material where the material has collectively risen above the ground or water at a hazardous materials incident.
9. **Plume** – Irregularly shaped pattern of an airborne hazardous material where wind and/or topography influence the downrange course from the point of release.
10. **Cone** – Triangular-shaped pattern of an airborne hazardous material release with a point source at the breach and a wide base downrange.
11. **Pressure Relief Device (PRD)** – An engineered valve or other device used to control or limit the pressure in a system or vessel, often by venting excess pressure.
12. **Confined Space** – Space or enclosed area not intended for continuous occupation, having limited (restricted access) openings for entry or exit, providing unfavorable natural ventilation and the potential to have a toxic, explosive, or oxygen-deficient atmosphere.
13. **Ring Stiffener** – Circumferential tank shell stiffener that helps to maintain the tank cross section.
14. **Maximum Allowable Working Pressure (MAWP)** – A percentage of a container's test pressure. Can be calculated as the pressure that the weakest component of a vessel or container can safely maintain.
15. **High-Hazard Flammable Trains (HHFT) –** Trains that have a continuous block of twenty or more tank cars loaded with a flammable liquid or thirty-five or more cars loaded with a flammable liquid dispersed through a train.
16. **Railcar Initials and Numbers** – Combination of letters and numbers stenciled on rail tank cars that may be used to get information about the car's contents from the railroad's computer or the shipper. *Also known as* Reporting Marks.
17. **Dedicated Tank Car** – Rail tank car that is specked to meet particular parameters unique to the product including pressure relief device, linings, valves, fittings, and attachments. This type of car is often used for a single specified purpose for the life of the car, and may be marked to indicate that exact purpose.
18. **Capacity Stencil** – Number stenciled on the exterior of a tank car to indicate the volume of the tank.
19. **Specification Marking** – Stencil on the exterior of a tank car indicating the standards to which the tank car was built; may also be found on intermodal containers and cargo tank trucks.
20. **Intermodal Container** – Freight containers designed and constructed to be used interchangeably in two or more modes of transport. *Also known as* Intermodal Tank, Intermodal Tank Container, *and* Intermodal Freight Container.
21. **Refrigerated Intermodal Container** – Cargo container having its own refrigeration unit. *Also known as* Reefer.
22. **Excepted Packaging –** Container used for transportation of materials that have very limited radioactivity. *See* Industrial Packaging, Packaging (1), Strong, Tight Container, Type A Packaging, and Type B Packaging.

23. **Dewar** – All-metal container designed for the movement of small quantities of cryogenic liquids within a facility; not designed or intended to meet Department of Transportation (DOT) requirements for the transportation of cryogenic materials.

Hazardous Materials for First Responders Fifth Edition

Chapter 6 — Planning the Response: Identifying Action Options

HAZARDOUS MATERIALS FOR FIRST RESPONDERS
FIFTH EDITION

IFSTA

Learning Objective 1

Explain predetermined procedures.

6–1

The initial response can make the difference between solving the problem and becoming part of it.

Courtesy of the U.S. Air Force

6–2

Predetermined procedures and SOP/Gs are important at hazmat incidents.

SOP/Gs should include considerations for

- Chemical responses
- Biological responses
- Radiological/nuclear responses
- Explosives/explosive materials responses
- WMD responses
- Significant incident responses

6–3

Following predetermined procedures reduces chaos on the hazmat scene.

- Establishes accountability and increases command and control effectiveness
- Helps prevent duplication of effort and uncoordinated operations
- Describes assumption and transfer of command, communications procedures, and tactical procedures
- Defines your role according to your training level at emergency incidents, including those involving hazardous materials

6–4

Responders should be familiar with their agency's emergency response plan and SOPs/SOGs.

Courtesy of the U.S. Air Force

6–5

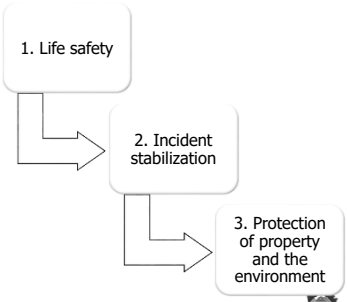
REVIEW QUESTION

How do predetermined procedures assist a first responder at a hazmat incident?

Learning Objective 2

List incident priorities for hazardous materials incidents.

All hazmat incidents have three incident priorities.



NOTE

A fourth priority, societal restoration, is sometimes added to this list to ensure that the recovery phase of major incidents is considered from the beginning.

All plans must consider these incident priorities.

Keep in mind that

- Incidents are dynamic
- Priorities may change according to situation
- You should never risk your life to save property that is replaceable or cannot be saved

NOTE

Never risk your life to save property that is replaceable or cannot be saved.

REVIEW QUESTION

What are the three priorities for hazmat incidents?

6–12

Learning Objective 3

Describe the process of size-up and hazard and risk assessment.

6–13

Upon arrival at the incident, the IC must size-up the incident.

Size-up is the mental process of considering all available factors that will affect an incident during operations

Information gained from size-up used to determine the response objectives (strategies) and action options (tactics)

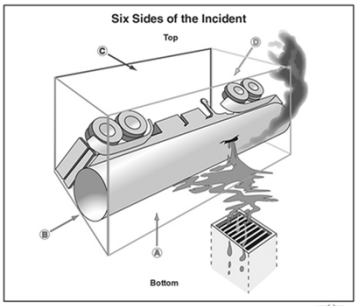
6–14

Hazard and risk assessment is part of the size-up process.

- Focuses particularly on dangers, hazards, and risks present
- Continual evaluation
- Starts with preincident planning
- Continues throughout the incident response

6–15

Size-up must consider all six sides of an incident.



6–16

Gather information before reporting the incident.

- Number and type of injuries
- Occupancy type
- Type of incident
- Product and container information if available
- Location of the incident
- Equipment and resources responding
- Time of day
- Weather

6–17

Additional pieces of information are useful.

- Wind direction
- Topography
- Land use
- Presence of victims
- Equipment access
- Available response personnel

6–18

The initial survey should consider the following questions, when appropriate.

- Where is the incident scene in relation to population, environmental, and property exposures?
- Is the incident scene inside a building or outside?
- What are the hazardous materials?
- Is it a terrorist attack or other criminal incident?
- What hazard classes are involved?

(Cont.)

6–19

The initial survey should consider the following questions, when appropriate.

- What quantities are involved?
- What concentrations are involved?
- How could the material react?
- What containers are involved?
- How is the material likely to behave?
- Is it a liquid or solid spill or a gas release?
- Is something burning?

(Cont.)

6–20

The initial survey should consider the following questions, when appropriate.

- What kind of container holds the material?
- What is the condition of the container?
- How much time has elapsed since the incident began?
- Can we anticipate where the product is going? Where will it be in 10 minutes, 30 minutes, 60 minutes?
- What personnel, equipment, and extinguishing agents are available?
- Is there private fire protection or other help available?

(Cont.)

6–21

The initial survey should consider the following questions, when appropriate.

- What effect can the weather have?
- Are there nearby lakes, ponds, streams or other bodies of water?
- Are there overhead wires, underground pipelines, or other utilities?
- Where are the nearest storm and sewer drains?
- What has already been done?
- What would be the end result if no action was taken?

6–22

When the incident requires a rescue, consider additional variables.

- Risk to rescuers
- Ability of rescuers to protect themselves
- Probability of rescue
- Difficulty of rescue
- Capabilities and resources of on-scene forces
- Possibilities of explosions or sudden material releases
- Available escape routes and safe havens
- Constraints of time and distance

6–23

Responders can predict hazardous material behavior given its state of matter and environmental conditions.

Courtesy of Steve Irby, Owasso (OK) Fire Department

6–24

Use approved resources to determine the level of risk presented by the specific hazardous material.

After the material has been identified, responders can use references to determine the health and physical hazards presented by the material

- SDSs
- Shipping papers with emergency response information
- Other written or computer references
- Generic information provided by the *ERG*

6–25

Responders can estimate the size of the endangered area and predict potential exposures.

Courtesy of Rich Mahaney

- Number of people
- Buildings
- Property
- Environmental concerns

6–26

Situational awareness is a continuous process.

Size-up

Interpreting signs

Assessing what is happening over the life of the incident

Predicting outcomes based on a plan of action

6–27

Situational awareness includes interpreting, assessing, and predicting.

Courtesy of M.S.A.

6–28

Situational awareness is sometimes referred to as a process working at three levels.

Level 1: Perception	• Perceive the situation around us
Level 2: Comprehension	• Apply our knowledge and past experiences to our perception and develop an understanding of the meaning of the situation
Level 3: Application	• Take our understanding of the situation and apply it to the future, thereby predicting how and when the situation will change and what action is appropriate on our part

6–29

Avoid factors than can contribute to loss of situational awareness.

Ambiguity	• Information received is confusing or unclear
Distraction	• Loss of focus of the original mission without appropriate rationale
Fixation	• Too focused on a single element of the situation to the exclusion of all others
Overload	• Tasks or information overwhelm us, or we attempt to perform all the tasks ourselves

(Cont.)

Avoid factors than can contribute to loss of situational awareness.

Complacency	• False sense of comfort based on a misconception of the hazard, risk, or situation
Improper procedure	• Policies or procedures are violated or ignored without justification
Unresolved discrepancy	• Two or more pieces of information do not agree
Lack of comprehensive hazard surveillance	• Crew members become so fixated on one detail that they ignore everything else

Proper situational awareness depends on performing specific actions.

- Maintain effective communications
- Recognize and make others aware of any deviation from SOP/Gs
- Monitor crew member performance
- Provide information in advance of an operation or mission
- Identify any potential problems or existing hazards
- Communicate the desired course of action
- Communicate the mission's status continuously
- Evaluate the situation for any changes continually
- Clarify expectations of crew members continually

REVIEW QUESTION

Explain the three levels of perceptual awareness.

Learning Objective 4

Define hazardous materials incident levels.

After the scope of an incident has been determined, the level of the incident can be determined.

Level 1	• Within the capabilities of the fire or emergency services organization or other first responders having jurisdiction
Level 2	• Beyond the capabilities of the first responders on the scene and may be beyond the capabilities of the first response agency/organization having jurisdiction
Level 3	• Requires resources from state/provincial agencies, federal agencies, and/or private industry and also requires unified command

A Level I incident is the least serious and the easiest to handle.

May pose a serious threat to life or property, although this situation is not usually the case

Evacuation (if required) is limited to the immediate area of the incident

6–36

A small gasoline spill is a Level I incident.

Courtesy of Rich Mahaney

6–37

Level II incidents may require a formal hazmat response team.

A properly trained and equipped response team could be expected to

- Use chemical protective clothing
- Dike and confine within the contaminated areas
- Perform plugging, patching, and basic leak control activities
- Sample and test unknown substances
- Perform various levels of decontamination

6–38

A Level II incident might require chemical protective clothing or testing an unknown substance.

Courtesy of New South Wales Fire Brigades

6–39

A Level III incident is the most serious of all hazardous material incidents.

Successful handling of the incident requires a collective effort from several of the following resources/procedures

- Specialists from industry and governmental agencies
- Sophisticated sampling and monitoring equipment
- Specialized leak and spill control techniques
- Decontamination on a large scale

6–40

To mitigate most Level III incidents, more than one agency will be needed.

Courtesy of the U.S. Department of Defense

6–41

REVIEW QUESTION

Give examples of Levels I, II, and III hazmat incidents.

6–42

Learning Objective 5

Explain the three modes of operations at hazardous materials incidents.

6–43

Strategies are divided into three options that relate to modes of operation.

Nonintervention	• Allows the incident to run its course on its own
Defensive	• Provides confinement of the hazard to a given area by performing diking, damming, or diverting actions
Offensive	• Includes actions, such as plugging a leak, to control the incident

6–44

Leak control is an offensive action.

6–45

When selecting a mode of operation, the safety of first responders is the utmost consideration.

Selection of the strategic mode is based on

- Risk to responders
- Responders' level of training
- Balance between resources required and those available

6–46

In nonintervention operations, responders do not take direct action on the actual problem.

Nonintervention mode is selected when one or more of the following circumstances exist

- A preincident evaluation calls for it
- The situation is clearly beyond the capabilities of responders
- Explosions are imminent
- Serious container damage threatens a massive release

6–47

Nonintervention is an acceptable strategy at some incidents.

Courtesy of the U.S. Corps of Engineers

6–48

In nonintervention situations, responders should take specific actions.

- Withdraw to a safe distance
- Report scene conditions to telecommunications center
- Initiate an incident management system
- Call for additional resources as needed
- Isolate the hazard area and deny entry
- Begin evacuations when needed

6–49

In defensive operations responders seek to confine the emergency without directly contacting the hazardous materials.

The defensive mode is selected when one of the following two circumstances exists

- The facility or LERP calls for it based on a preincident evaluation of the hazards present at the site
- Responders have the training and equipment necessary to confine the incident to the area of origin

6–50

Defensive operations aim to confine the emergency.

6–51

In defensive operations, operations level first responders should take specific actions.

- Report scene conditions to the telecommunications center
- Initiate an incident management system
- Call for additional resources as needed
- Isolate the hazard area and deny entry

(Cont.)

6–52

In defensive operations, operations level first responders should take specific actions.

- Establish and indicate zone boundaries
- Begin evacuation where needed
- Control ignition sources
- Use appropriate defensive control tactics

(Cont.)

6–53

In defensive operations, operations level first responders should take specific actions.

- Protect exposures
- Perform rescues when safe and appropriate
- Evaluate and report incident progress
- Perform emergency decontamination procedures

6–54

Offensive operations are those where responders take aggressive, direct action.

May result in contact with the material and require responders to wear appropriate chemical-protective clothing and respiratory protection

Some offensive operations are beyond the scope of responsibilities for first responders and are conducted by more highly trained personnel

6–55

Offensive operations may involve contacting the hazardous material.

6–56

REVIEW QUESTION

What factors are considered when determining the mode of operation?

6–57

Learning Objective 6

Identify methods for planning the initial response.

6–58

The IC must use incident analysis information to plan the response.

Aspects relevant to planning the initial response include

- Response models
- Risk-based response
- Developing the IAP

6–59

Using a response model can help simplify the problem-solving process.

Most response models incorporate an entire problem-solving process

- An information gathering or input stage
- A processing or planning stage
- An implementation or output stage
- A review or evaluation stage

6–60

APIE is a simple response model containing the basic four-step problem solving process model elements.

1. Analyze the incident
2. Plan the initial response
3. Implement the response
4. Evaluate progress

6–61

A risk-based response uses information, science, and technology to mitigate a hazardous materials incident.

- Hierarchy of decisions needed to protect responders
- Starts with a thorough size-up, identifying the immediate hazards so that decisions can be made in a logical and educated manner
- Quick and efficient way to "thin slice" information and make educated, lifesaving decisions

6–62

Incident Action Plans (IAPs) are critical to the rapid, effective control of emergency operations.

Well-thought-out, organized course of events developed to address all phases of incident control within a specified time

Large scale or complex incidents require the creation and maintenance of a written plan for each operational period

6–63

Large scale, complex incidents may require a written IAP.

Courtesy of Phil Linder

Action planning starts with identifying the response objective (strategy) to achieve a solution to the confronted problems

Command Staff then selects the action options (tactics, the how, where, and when) to achieve the objective

6–64

Once a strategy has been defined, the Command Staff selects actions options to achieve the objectives.

Action options are measureable in

- Time
- Performance

6–65

An IAP includes many elements.

Strategies/ incident objectives	Current situation summary	Resource assignment and needs	Accomplishments
Hazard statement	Risk assessment	Safety plan and message	Protective measures
Current and projected weather conditions	Status of injuries	Communications plan	Medical plan

6–66

REVIEW QUESTION

List the elements of an IAP.

6–67

Learning Objective 7

Distinguish common response objectives and action options at hazardous materials incidents.

6–68

An IAP requires response objectives and action options.

Response objectives
- Strategies
- Broad statements of what must be done to resolve an incident

Action options
- Tactics
- Specific operations that must be done in order to accomplish those goals

6–69

Response objectives must be selected based on specific criteria.

Response objective must be able to

- Be achieved
- Prevent further injuries and/or deaths
- Minimize environmental and property damage within the constraints of safety, time, equipment, and personnel

6–70

Understand additional risk-based response principles.

Activities that present a significant risk to the safety of members shall be limited to situations where there is a potential to save endangered lives

Activities that are routinely employed to protect property shall be recognized as inherent risks to the safety of members, and actions shall be taken to reduce or avoid these risks

No risk to the safety of members shall be acceptable when there is no possibility to save lives or property

6–71

Some response objectives are common at hazmat incidents.

Isolation	Notification	Identification	Protection (life safety)
Rescue	Spill control/ confinement	Leak control/ containment	Crime scene and evidence preservation
	Fire control	Recovery/ termination	

6–72

Response objectives are prioritized depending on available resources and the particular details of the incident.

Rescue is a response objective at some hazmat incidents

6–73

Action options are the specific tactics that are used to accomplish response objectives.

Action options are the tasks that you will be asked to perform in order to mitigate the incident

6–74

Typical hazmat problems have some common potential response objectives and action options.

Table 6.1
Typical Hazmat Problems with Potential Response Objectives and Action Options

Problem	Strategies	Tactics
Access: Access problems may be related to gaining access or denying access (to civilians or unprotected responders). Generally the first problem presented is limiting access to civilians and unprotected responders.	Isolate and deny entry	• Establish control zones (Hot and Cold) • Control traffic
Container Under Stress: The two types of container stress that responders can readily affect are generally thermal stress (heating) and mechanical stress (due to overpressure).	Ignore	Protect exposures (protective actions only)
	Cool	• Use master stream • Use hoseline
	Extinguish fire	• Remove fuel • Use master stream • Use hoseline • Use foam master stream • Use foam hoseline
	Release pressure	• Transfer product • Release product to atmosphere • Vent and burn

(Cont.)

6–75

Typical hazmat problems have some common potential response objectives and action options.

Container Breach/Release: Active strategies to manage a breach/release generally require operations inside the hazard area (Hot Zone).	Ignore	Protect exposures (protective actions only)
	Contain	• Close valve(s) • Tighten attachments • Plug • Patch • Transfer product • Decontaminate (required for entry)
Dispersion: Active strategies to control dispersion may be either offensive or defensive (depending on where they are performed). Dispersion control strategies are driven by the form of the material that has been (or is being) released.	Ignore	Protect exposures (protective actions only)
	Confine: Solid	Cover
	Confine: Liquid	• Adsorb or absorb • Dike (Circle or V-shape) • Divert • Retain • Dam (underflow or overflow) • Suppress vapor (foam)
	Confine: Energy	Shield
	Disperse: Gas	Disperse vapor (water fog or blower)

(Cont.)

6–76

Typical hazmat problems have some common potential response objectives and action options.

Table 6.1 (concluded)

Problem	Strategies	Tactics
Fire: The fire problem includes a direct threat to life safety and exposures, potential to affect container integrity, and release of toxic products of combustion. However, in some cases (pesticides), fire may present less threat than fire-control operations.	Ignore	Protect exposures (protective actions only)
	Extinguish	• Use master stream • Use hoseline • Use foam master stream • Use foam hoseline • Use dry chemical • Use specialized extinguishing agent
Possible Victims: Possible victims may be reported (definitely a known imminent life threat) or inferred based on incident conditions. Victims removed from the hazard area (Hot Zone) may require decontamination.	Determine	Ask
	Notify	• Use public address system • Use telephone
	Locate	• Perform primary search/extraction • Perform decontamination • Perform secondary search
Visible/Known Victims: Victims may be visible or known to be inside the hazard area. These victims may (or may not) be able to rescue themselves. First responders must use care in assessing their capability to effect a rescue (due to limitations in personal protective equipment and training. Victims removed from the hazard area (Hot Zone) may require decontamination.	Rescue	• Rescue themselves • Move to safe refuge • Perform extraction • Perform decontamination

(Cont.)

6–77

Typical hazmat problems have some common potential response objectives and action options.

Potential Life Exposure: Potential victims may become exposed due to dispersion (downhill or downwind). Responders must consider dispersion, time, and incident conditions in evaluating potential life exposure.	Protect in place	• Notify face to face • Notify by telephone • Notify media
	Evacuate	• Notify face to face • Notify by telephone • Notify media • Shelter • Control traffic • Perform security
Environmental/Property Exposure: Active strategies to minimize environmental/ property damage are generally offensive in nature.	Ignore	Self-mitigate
	Control chemical	• Dilute • Neutralize
	Cool	• Use master stream • Use hoseline • Use foam master stream • Use foam hoseline

6–78

Responders must be able to determine if their PPE is adequate to perform assigned tasks.

If PPE is determined to be inadequate

→ IAP will need to be revised

6–79

PPE requirements may differ depending on incident specifics.

- Responder's mission/assignment
- Product(s) involved
- Circumstances at the incident, for example, in a confined space

6–80

Emergency decontamination may be required.

If responders or the public come into contact with (or potentially contact) hazardous materials

May be necessary to remove the hazardous material as quickly as possible

Process is called **emergency decontamination** (emergency decon)

6–81

REVIEW QUESTION

What is the difference between a response objective and an action option?

6–82

Chapter 6: Planning the Response: Identifying Response Options Answers
Key Terms

1. **Hazard and Risk Assessment** – Formal review of the hazards and risks that may be encountered by firefighters or emergency responders; used to determine the appropriate level and type of personal and respiratory protection that must be worn. *Also known as* Hazard Assessment.
2. **Nonintervention Operations –** Operations in which responders take no direct actions on the actual problem.
3. **Defensive Operations –** Operations in which responders seek to confine the emergency to a given area without directly contacting the hazardous materials involved.
4. **Offensive Operations** – Operations in which responders take aggressive, direct action on the material, container, or process equipment involved in an incident.
5. **Risk-Based Response** –Method using hazard and risk assessment to determine an appropriate mitigation effort based on the circumstances of the incident.
6. **Response Objective** – Statement based on realistic expectations of what can be accomplished when all allocated resources have been effectively deployed that provide guidance and direction for selecting appropriate strategies and the tactical direction of resources.
7. **Action Option** – Specific operations performed in a specific order to accomplish the goals of the response objective.
8. **Emergency Decontamination** – The physical process of immediately reducing contamination of individuals in potentially life-threatening situations, with or without the formal establishment of a decontamination corridor.

Fill in the Blank

1. Incident Action Plan (or IAP)
2. flexibility
3. training level
4. location
5. dynamic

Picture Identification

Part I: Modes of Operation
1. Offensive
2. Offensive
3. Defensive
4. Offensive
5. Defensive
6. Nonintervention
7. Defensive
8. Nonintervention

Matching

Part I: Levels of Situational Awareness
1. A
2. B
3. B

4. A
5. B
6. A

Part II: Incident Levels

1. B
2. C
3. A
4. B
5. A

Part III: Response Objectives and Action Options

1. F
2. B
3. E
4. F
5. D
6. B
7. A
8. B

Short Answer

Answers should include all of the following:
Number and type of injuries
Occupancy type
Type of incident
Product and container information, if available
Location of the incident
Equipment and resources responding
Time of day
Weather
Answers may vary; students should include 2 of the following.
Wind direction
Topography
Land use
Presence of victims
Equipment access
Available response personnel
Answers may vary; students should include 4 of the following.
Risk to rescuers
Ability of rescuers to protect themselves
Probability of rescue
Difficulty of rescue
Capabilities and resources of on-scene forces
Probabilities of explosions or sudden material releases
Available escape routes and safe havens
Constraints of time and distance

4 *Answers may vary; students should include 3 of the following.*
Safety data sheets (SDSs)
Shipping papers
Emergency Response Guide (ERG)
Manufacturer of material
Emergency response centers (CHEMTREC, CANUTEC, or SETIQ)

5. *Answers may vary; students should include 5 of the following.*
Strategies/incident objectives
Current situation summary
Resource assignment and needs
Accomplishments
Hazard statement
Risk assessment
Safety plan and message
Protective measures
Current and projected weather conditions
Status of injuries
Communications plan
Medical plan

Hazardous Materials for First Responders
Fifth Edition

Chapter 7 — Implementing and Evaluating the Action Plan: Incident Management and Response Objectives and Action Options

HAZARDOUS MATERIALS FOR FIRST RESPONDERS
FIFTH EDITION

IFSTA

Learning Objective 1

Describe the NIMS-ICS organizational functions that help initiate incident management.

7–1

A crucial step in implementing the action plan is initiating the Incident Management System.

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)

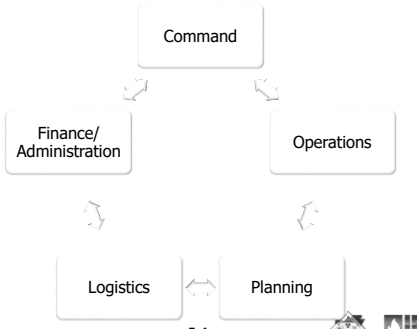
7–2

NIMS-ICS is designed to be applicable to both very small and very large incidents.

At an incident, NIMS-ICS provides	Modular organization
	Manageable span of control
	Organizational facilities such as a command post and staging areas
	Standardized position titles
	Integrated communications
	Accountability of resources

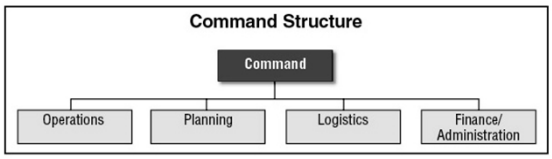
7–3

NIMS-ICS involves five major organizational functions.



7–4

Command has the delegated authority to direct, order, and control resources.



7–5

The basic Command organization configuration includes three levels.

Strategic level
- Entails the overall direction and goals of the incident

Tactical level
- Identifies objectives that the tactical level supervisor/ officer must achieve to meet the strategic goals

Task level
- Describes specific tasks needed to meet tactical-level requirements and assigns these tasks to operational units, companies, or individuals

7–6

The Incident Commander is in overall charge of the incident.

The Incident Commander's responsibilities include

- Keeping an up-to-date report for the emergency scene
- Establishing the Command Post (CP) and formulating the Incident Action Plan
- 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

7–7

ICs at hazmat incidents have additional responsibilities.

- Establish the site safety (scene safety) plan
- Implement a site security and control plan to limit the number of personnel operating in the control zones
- Designate a Safety Officer
- Identify the materials or conditions involved in the incident
- Implement appropriate emergency operations
- Ensure that all emergency responders (wear appropriate personal protective equipment (PPE) in restricted zones
- Establish a decontamination plan and operation
- Implement post-incident emergency response procedures

7–8

If the incident is large and/or complex, the IC may delegate authority to some command staff positions.

7–9

The Safety Officer has multiple responsibilities.

- Identify and monitor hazardous and unsafe situations
- Ensure operational and personnel safety
- Obtain a briefing from the IC
- Review IAPs for safety issues
- Identify hazardous situations at the incident scene
- Participate in the preparation and monitoring of incident safety considerations, including medical monitoring of entry team personnel before and after entry

7–10

The Safety Officer monitors the scene for unsafe conditions.

- Maintain communications with the IC, and advise the IC of deviations from the incident safety considerations and of any dangerous situations
- Alter, suspend, or terminate any activity that is judged to be unsafe
- Conduct safety briefings

7–11

The Safety Officer conducts safety briefings with entry team members before they enter hazardous areas.

7–12

The Safety Officer must ensure that safety briefings are conducted for entry team personnel before entry.

Safety briefings include information about the incident

- Identification of hazards
- Description of the site
- Tasks to be performed
- Anticipated duration of the tasks
- PPE requirements
- Monitoring requirements
- Notification of identified risks
- Additional pertinent information

7–13

There are additional safety briefing requirements at incidents involving potential criminal or terrorist activities.

Be alert for secondary devices
Do not touch or move any suspicious-looking articles
Do not touch or enter any damp, wet, or oily areas
Wear full protective clothing, including SCBA
Limit the number of personnel entering the crime scene
Document all actions
Do not pick up or take any souvenirs
Photograph or videotape anything suspicious
Do not destroy any possible evidence
Seek professional crime-scene assistance

7–14

The Command Post (CP) should be established at a safe location.

Courtesy of Ron Jeffers

7–15

A CP ensures that the IC is accessible.

Command Post	Can be a predetermined location
	Ideally will allow the IC to observe the scene
	Location relayed to the telecommunicator/ dispatcher and emergency responders
	Needs to be readily identifiable

7–16

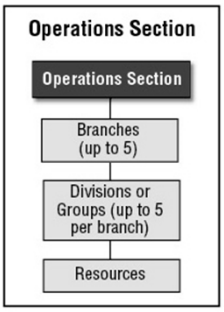
A CP needs to be readily identifiable with common identifiers.

Common identifiers include

- Custom designed command vehicles, or removable vehicle signage
- Marked building or tent
- Pennants, flags, or signs
- Marking lights, such as vehicle hazard lights

7–17

The Operations Section is responsible for managing all operations that directly affect the primary mission.



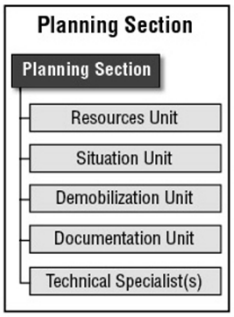
The Operations Section directly manages all incident tactical activities, the tactical priorities, as well as the safety and welfare of personnel working in the Operations Section

The Operations section establishes and maintains the Staging Area.

Staging Area

- Where personnel (and equipment) awaiting assignment are held
- Keeps responders and their equipment a short distance from the scene until they are needed
- Minimizes confusion at scene

The Planning Section serves as the IC's clearinghouse for incidents.



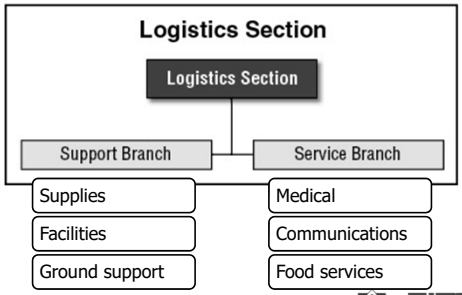
The Planning Section gathers, assimilates, analyzes, and processes information needed for effective decision-making

The Logistics Section is the support mechanism for the organization.

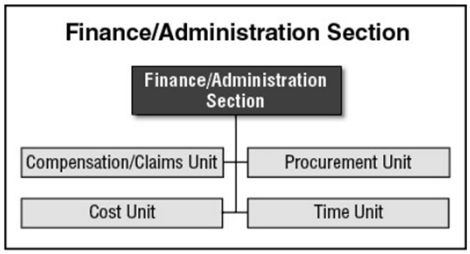
Provides services and support systems to all the organizational components involved including

- Facilities
- Transportation needs
- Supplies
- Equipment
- Maintenance
- Fueling supplies
- Meals
- Communications
- Responder medical services

Support Branch and Service Branch are two branches within the logistics section.

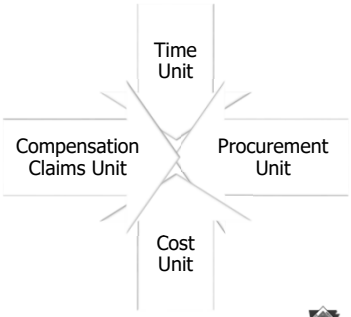


The Finance/Administration is established only if needed.



At large-scale, long-term incidents, the Finance/Administration Section is often activated

Finance/Administration Section includes specific units.



7–24

REVIEW QUESTION

List five major organizational functions of NIMS-ICS that help initiate incident management and identify their major responsibilities or activities.

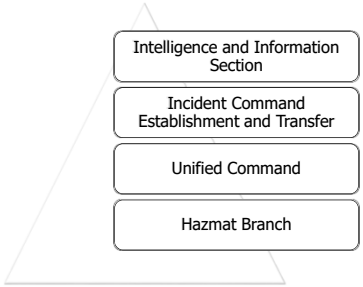
7–25

Learning Objective 2

Describe secondary NIMS-ICS organizational functions.

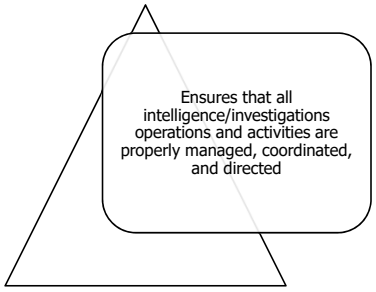
7–26

NIMS-ICS includes secondary organizational functions.



7–27

The Intelligence and Information Section is established at incidents when WMDs or criminal activities are suspected.



7–28

The Intelligence and Information Section's activities help authorities at the crime scene.

Helps authorities to	Prevent/deter potential unlawful activity, incidents, and/or attacks
	Collect, process, analyze, secure, and appropriately disseminate information and intelligence
	Identify, document, process, collect, create a chain of custody for, safeguard, examine, analyze, and store probative evidence
	Conduct a thorough and comprehensive investigation that leads to the identification, apprehension, and prosecution of the perpetrators
	Serve as a conduit to provide situational awareness (local and national) pertaining to an incident
	Inform and support life safety operations

7–29

IMS specifies incident command establishment and transfer.

The first person on the scene or the ranking individual of the first company on the scene assumes Command of the incident

That individual maintains Command until a higher ranking or more extensively trained responder arrives on the scene and assumes Command

Before transferring Command, the IC must ensure that the new IC is both capable of assuming Command and willing to accept Command

7–30

The IC must have IMS training and be trained at the hazardous materials Operations level.

7–31

As an incident grows larger, Command may be transferred several times before the situation is controlled.

The person relinquishing Command must provide the person assuming Command with as clear of a picture of the situation as possible

The person assuming Command acknowledges receipt of the information by repeating it back to the current IC

7–32

Unified Command is used when an incident involves multiple agencies.

Unified Command means that all agencies that have a jurisdictional responsibility at a multijurisdictional 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

7–33

Controlling hazardous material incidents may require coordinated efforts of several agencies/organizations.

- Fire service
- Law enforcement
- EMS
- Private concerns
- Government agencies
- Privately contracted cleanup and salvage companies
- Specialized emergency response groups, organizations, and technical support groups
- Utilities and public works

7–34

Before an incident occurs, agencies can take actions to avoid jurisdictional and command disputes.

Identify the specific agency/organization responsible for handling and coordinating response activities

Know what your mutual-aid contracts cover

Plan your preincident coordination at the local level

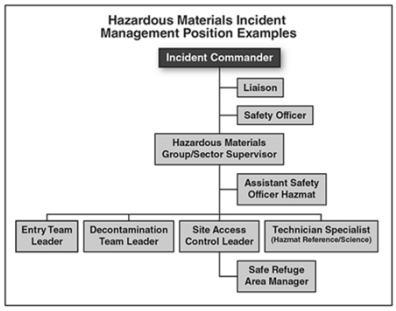
Document the identities and capabilities of nearby support sources

7–35

When organizations work together to develop preincident surveys, they can focus on specific objectives.

- Share vital resource information
- Develop rapport among participating emergency services organizations
- Identify and pool needed resources

Hazmat functions will be based on the AHJ and the needs of the IC at the scene.



REVIEW QUESTION

List four secondary organizational functions of NIMS-ICS and identify their major responsibilities or activities.

Learning Objective 3

Explain ways of 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.

Tactics

- Developed once strategies are in place
- Operational tasks that are used to accomplish strategies
- Should be measureable in both time and performance
- Should be evaluated to ensure that they will meet strategic goals

Some typical hazmat strategies and tactics are presented in the following sections.

- Notification
- Isolation and scene control
- Hazard-control zones
- Protection of responders
- Protection of the public
- Protection of the environment and property
- Product control
- Fire control
- Emergency decontamination
- Evidence preservation

Responders must understand their role in notification processes and predetermined procedures.

Notification may include actions such as incident-level identification and public emergency information/notification

It is better to dispatch more resources than necessary in an initial response to ensure appropriate weight of attack to combat incident conditions

Responders should be familiar with the assets available in their jurisdictions

Responders must know the procedure to request additional assets

7–42

Notification may involve multiple procedures.

Contacting law enforcement whenever a terrorist or criminal incident is suspected

Notifying other agencies (such as public works and the local emergency operations center) that an incident has occurred

Procedures will differ depending on the AHJ

Always follow SOPs and emergency plans for notification procedures

7–43

In the U.S. the notification process is detailed in the National Response Framework (NRF).

All local, state, and federal emergency response plans must comply with these provisions

While incidents are handled at the lowest geographic, organizational, and jurisdictional level, when local agencies need additional assistance, the hazmat IC or AHJ may request help

The local emergency response plan (LERP) is the first resource responders in the U.S. should turn to if they need to request outside assistance

The local response agency should be closely tied with the community's Emergency Operations Center (EOC)

7–44

Notification and requests for assistance processes should be predetermined.

Resources that may be requested to help at hazmat/WMD incidents in the U.S include

- Weapons of Mass Destruction-Civil Support Teams (WMD-CST)
- Disaster Medical Assistance Teams (DMAT)
- Disaster Mortuary Operational Response Teams (DMORT)
- National Medical Response Team-Weapons of Mass Destruction (NMRT-WMD)
- National Guard Chemical, Biological, Radiological, Nuclear and High Yield Explosive (CBRNE) Enhanced Response Force Package (CERFP)
- Urban Search and Rescue (US&R) Task Forces
- Incident Management Teams (IMT)

7–45

DMAT teams provide professional and paraprofessional medical personnel during disasters.

Courtesy of Ron Jeffers

7–46

The isolation perimeter is a flexible construct.

Isolation perimeter

- 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

7–47

NOTE

From a risk-management perspective, it is better to encompass a larger area that can be reduced in size once incident-site conditions have been assessed for risks such as secondary devices, unidentified hazardous materials, and atmospheric monitoring.

7–48

The initial isolation perimeter is usually determined by the outcomes of an on-site risk assessment.

The isolation perimeter is used to control both access and egress from incident site

Scene control includes the establishment of hazard-control zones and staging areas

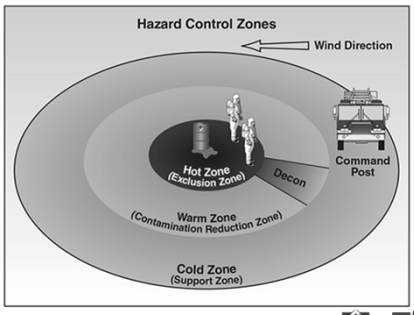
7–49

Hazard-control zones provide the scene control required at hazmat and terrorist incidents.

- Prevent interference by unauthorized persons
- Help regulate first responders' movements within the zones
- Minimize contamination (including secondary contamination from exposed or potentially exposed victims)
- Help ensure accountability of all personnel operating at large, multiagency response incidents

7–50

Hazard-control zones divide the levels of hazard at an incident.



7–51

Control zones take whatever shape is needed.

Control zones

- Shape often dictated by the features of the location and incident
- Not necessarily static, can be adjusted as the incident changes
- Referred to as site work zones or scene-control zones by some agencies
- Other countries may use different terminology for these zones

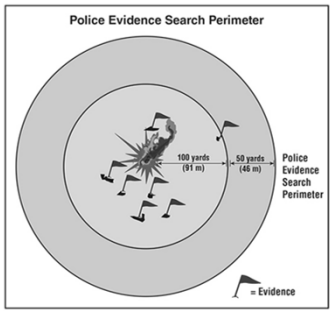
7–52

At incidents involving crimes, law enforcement may designate a zone to incorporate the entire crime scene.

- This zone may not correspond to traditional fire service activities
- These law enforcement zones might change as evidence is processed and the crime scene is released
- When establishing these zones, the crime scene dynamics may create a need for flexibility on the part of all agencies in the Unified Command

7–53

Different agencies may have different control zone needs.

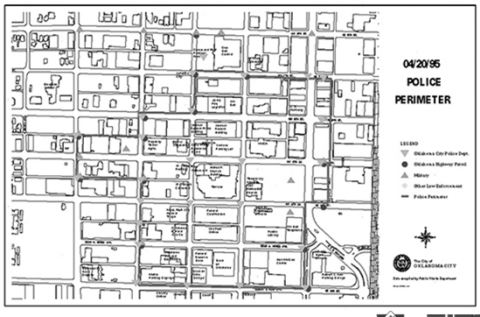


In the U.S., the FBI will establish a control perimeter at 1.5 times the distance of the farthest known piece of evidence

In incidents involving bombs, operations that are usually conducted within zones may vary.

- Because of the blast effects, there may be multiple buildings in danger of collapse, which will require the designation of a much larger hot zone
- In order to preserve evidence the hot zone be extended out as far as the perimeter of the debris field
- In these cases, there will likely be tight perimeter control and a large hot zone
- Responders may need to some conduct operations in an area designated as the hot zone

If evidence is widespread, the evidence perimeter may encompass a very large area.



A nontraditional scene management plan may be required at some unique incidents.

May be more than one hot zone

Incident Commander must remain flexible and establish a scene management plan and control zones to meet the needs of all of the responders to the incident

Responders at the incident must be made aware of control zones as they are established

The hot zone is also called the exclusion zone.

Hot zone

Area surrounding an incident that is potentially dangerous and/or contaminated

Responders must have proper training and wear appropriate PPE to work in the hot zone or to support work being done inside the hot zone

There will be established access and egress points to ensure both accountability and designated PPE prior to entry

The hot zone extends far enough to prevent people outside the zone from suffering ill effects.

Work performed inside the hot zone is often limited to highly trained personnel such as

- SWAT teams
- US&R teams
- Hazardous materials technicians
- Joint Hazard Assessment Teams (JHAT)
- Mission specific operations
- Bomb technicians

WARNING

Responders must have proper training and wear appropriate personal protective equipment (PPE) to work in the hot zone or to support work being done inside the hot zone.

7–60

The warm zone is also called the contamination reduction zone or corridor.

Warm zone

- Serves as a buffer between the hot and cold zones
- Decontamination location for personnel and equipment exiting the hot zone
- Monitoring and detection may be conducted around the perimeter of the warm zone

7–61

Decontamination typically takes place within the warm zone.

7–62

The cold zone is also called the support zone.

Cold zone

- Surrounds the warm zone
- Used to carry out all logistical support functions of the incident

7–63

The cold zone is the site for multiple activities.

- Multiagency Command post (CP)
- Staging area
- Donning/doffing area
- Backup teams
- Research teams
- Logistical support
- Criminal investigation teams
- Triage/treatment/rehabilitation
- Transportation areas

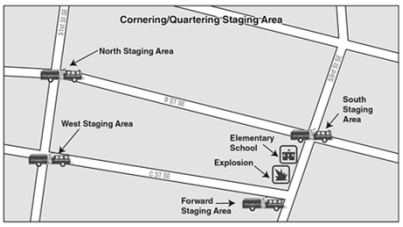
7–64

The staging area needs to be located in an isolated spot in a safe area.

- Staging minimizes confusion and freelancing at scene
- Should be located in the cold zone where occupants cannot interfere with ongoing operations
- Safe direction of travel to staging area should be broadcast to all resources responding to incident
- Ideally, emergency responders and equipment at terror incidents should be staged between multiple locations in case staging areas are attacked

7–65

Some departments use a cornering/ quartering staging procedure to spread their resources between multiple points.



7–66

Protection of responders is the first priority at any incident.

Measures to protect responders include

- Staying uphill, upstream, and upwind of hazardous materials
- Wearing appropriate PPE
- Using time, distance, and shielding for protection
- Decontaminating responders when necessary
- Ensuring accountability of all personnel
- Tracking and identifying all personnel working at an incident
- Working as part of a team or buddy system
- Assigning safety officers
- Putting evacuation and escape procedures in place

7–67

During a risk-based response, responders must wear appropriate PPE to protect against hazards.

The AHJ issues personal protection equipment

Responders must be

- Trained in its selection, use, and maintenance
- Aware of thermal issues such as heat stress

7–68

All personnel and equipment assigned to the incident must be tracked via an accountability system.

7–69

The IAP must contain a tracking and accountability system.

The accountability system must contain

- Procedure for checking in at the scene
- Way of identifying and tracking the location of each unit and all personnel on scene
- Procedure for releasing people, equipment, and apparatus that are no longer needed

7–70

You may encounter different types of accountability systems.

- Fire service passport systems
- T-card systems for wildland incidents
- GPS and GIS

7–71

NOTE

NFPA 1500 and 1561 address accountability system requirements.

NFPA and OSHA mandate the use of buddy systems and backup personnel at hazmat incidents.

Buddy system

- Organizes personnel into workgroups containing at least two members
- Primary benefit is to provide rapid help if there is an emergency

Backup system

- Backup personnel must be in place and prepared to enter the hot zone with appropriate equipment to provide assistance or rescue
- Backup personnel must be dressed in the same level of personal protective clothing as entry personnel

CAUTION

At a minimum, four appropriately trained and equipped responders are needed to perform tasks in the hot zone — two working in the area itself and two standing by as backup.

Using time, distance, and shielding is an effective strategy to protect first responders at hazmat incidents.

Time

- Limit time responders are exposed (or potentially exposed) to hazards and hazardous materials
- Restrict work times in the hot zone
- Frequently rotate personnel on work groups

Distance

- Maximize distance from potential hazards
- Distance may be controlled by implementing hazard-control zones

Shielding

- Place a physical barrier between responder and hazard
- May consist of wearing PPE or positioning personnel so that another object is between responder and the hazard

The FEMA US&R Task Force program has developed a system for evacuating rescuers from dangerous areas.

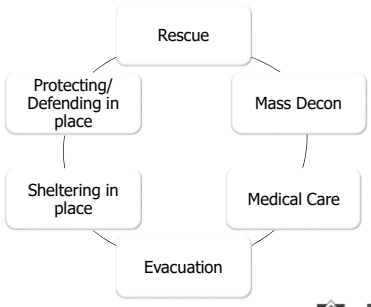
Notification of evacuation can be made using multiple methods

- Handheld CO_2 boat air horns
- Air horns on fire apparatus
- Vehicle horns
- Portable radios
- Voice
- Hand signals
- Other predetermined signals

Know the US&R designated signals and their meanings.

Cease Operations/ All Quiet	One long blast (three seconds)
Evacuate the Area	Three short blasts (one second each)
Resume Operations	One long and one short blast

Operations for protection of the public are selected by the IC, depending on the specifics of the incident.



7–78

Before attempting a rescue, carefully evaluate the situation.

Factors that affect the ability of a rescuer to conduct a rescue include	Nature of the hazardous material
	Severity of the incident
	Responder training
	Availability of appropriate PPE
	Availability of monitoring equipment
	Number of victims and their conditions
	Time needed to complete a rescue
	Tools, equipment, and other devices needed to effect the rescue

7–79

WARNING

Never rush to conduct a rescue without appropriate PPE, planning, and coordination under the direction of the AHJ.

7–80

Before attempting a rescue, carefully evaluate.

If the decision is made to attempt a rescue, safety should be a paramount concern

The IC makes decisions about rescue based on a variety of factors at the incident

Nature of the hazardous material and incident severity	Training	Availability of PPE

7–81

You may encounter viable victims that need decontamination.

Move as carefully as possible

Transfer to the care of medical responders located within the initial-isolation zone or hot zone

7–82

Many actions can be taken without risk of contamination

- Directing people to an area of safe refuge or evacuation point
- Instructing victims to move to an area that is less dangerous
- Directing contaminated or potentially contaminated victims to an isolation point, safe refuge area, safety shower, eyewash facility, or decontamination area
- Giving directions to a large number of people for mass decontamination
- Conducting searches during reconnaissance or defensive activities
- Conducting searches on the edge of the hot zone

7–83

First responders can direct contaminated or potentially contaminated victims to safety showers.

Courtesy of the U.S. Marine Corps; photo by Sgt J.A. Lee II

7–84

Know what to do if there are injured victims at the scene.

Always be aware of the

- Potential dangers of contamination
- Need to decontaminate as part of the treatment process

Follow local procedures for determining prioritization of emergency medical care and decontamination

7–85

To evacuate 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

7–86

The number of responders needed to perform an evacuation varies.

Evacuation can be an expensive, labor-intensive operation

Therefore, it is important to assign enough personnel resources to conduct it

7–87

The IC must address the multiple factors regarding large-scale evacuations.

Notification	• Alert the public of the need to evacuate and tell them where they should go
Transportation	• Plan, in advance, alternate means of transportation
Relocation facilities and temporary shelters	• Designate appropriate evacuation shelters in the local emergency response plan
Reentry	• Consider how people will be allowed to return to evacuated areas

7–88

Evacuation plans must include a way to provide transportation to individuals without a means to leave.

Courtesy of FEMA News Photos; photo by Win Henderson.

7–89

Evacuees must have some place to stay.

Courtesy of Andrea Bopher

7–90

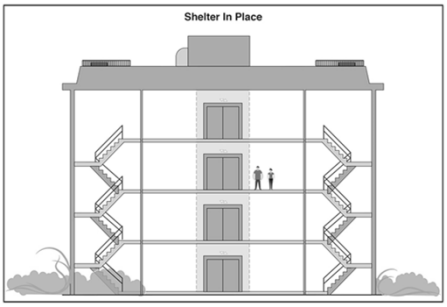
Some situations may make sheltering in place preferable to evacuation.

The decision to shelter in place may be influenced by factors such as

- The population is unable to initiate evacuation because of health care, detention, or educational occupancies
- The material is spreading too rapidly to allow time for evacuation
- The material is too toxic to risk any exposure
- Vapors are heavier than air, and people are in a high-rise or multi-level structure

7–91

When vapors and gases are heavier than air, it may be safest to shelter in place in multi-level structures.



7–92

Evacuation may be a better option than sheltering in place when explosive vapors or gases are involved.

These vapors or gases may take a long time to dissipate from the surrounding environment

Vapors or gases may permeate into any building that cannot be sealed from the outside atmosphere

7–93

Protecting/defending in place is an active role to physically protect those individuals in harm's way.

Actions that may be taken during this kind of operation include

- Using hose streams to diffuse a plume
- Securing a neighborhood or area
- Turning off HVAC systems to minimize spread of contaminants

7–94

Defending in place uses aggressive tactics to physically protect individuals in harm's way.

7–95

Exposure protection is a defensive control tactic.

Includes protecting the environment and protecting property that is threatened by an expanding incident

Protect exposures from fires involving hazardous materials

Protect the environment from the harmful effects of hazardous materials that are not burning

7–96

Diking a storm drain can protect the environment from harm.

7–97

Protecting the environment is an important concern.

The nonbiodegradable nature of many materials means that the consequences of contamination may take years for the full environmental effects to be realized

Contamination may also require large sums of money to repair

7–98

The threats to property may not always be readily evident.

Flammable and toxic gases, mists, and vapors can contaminate and pose an ignition threat with no visible signs

Protective actions must be tailored to the material, its properties, and any reactions to the proposed protective medium

7–99

Product control becomes necessary when hazardous materials escape their containers.

Product control strategies

- Offensive — Leak control
- Defensive — Spill control

7–100

Leak control attempts to keep a material in its original container.

7–101

Most hazmat incidents involve flammable materials.

Fire control

- 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

7–102

Incidents involving WMDs or other illegal activities are crimes.

Notify law enforcement as soon as a crime is suspected

Fire service first responders should not collect evidence

But need to identify and preserve evidence so that the investigator can collect and properly document it per the AHJ

7–103

Even seemingly irrelevant things can have tremendous significance to law enforcement investigators.

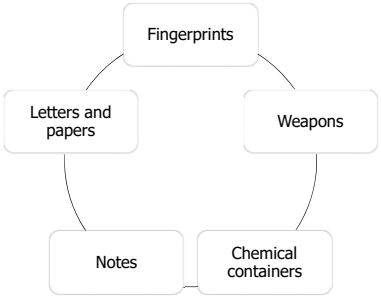
7–104

Evidence can take many forms.

- Items that look like trash may be pieces of a bomb or an incendiary device
- Can include everything from body fluids to tire tracks to cigarette butts
- Pattern of scattered debris may tell investigators about the force of an explosion
- Residue on debris can help identify what explosive materials were used
- Clothing and jewelry removed from victims are considered evidence

7–105

At illegal clandestine labs, evidence may include additional items.



7–106

As soon as criminal or terrorist activity is suspected, first responders should help preserve evidence.

- Avoid disturbing areas not directly involved in rescue activities
- Remember what the scene looked like upon first arrival as well as details about the progression of the incident — Note as many of the W's as possible
- Document observations as quickly as possible
- Take photographs and videos of the scene as soon as possible
- Remember and document when something was touched or moved
- Minimize the number of people working in the area if possible and establish travel routes that minimize disturbance

7–107

If a crime is suspected, take pictures of the incident scene and try to minimize how much the scene is disturbed.

7–108

Establishing travel routes through the scene can minimize disturbance

Courtesy of FEMA News Photos; photo by Jocelyn Augustino

7–109

Help preserve evidence.

- Leave fatalities and their surroundings undisturbed
- Isolate and secure areas where evidence is found, and report findings
- Identify witnesses, victims, and the presence of evidence
- Preserve potentially transient physical evidence
- Have evidence collection points located near decontamination corridors and hot zone exit locations
- At chemical or biological incidents, secure and isolate restaurants or food vendors near the incident area
- Follow predetermined procedures regarding operations at crime scenes

7–110

REVIEW QUESTION

What are common hazmat response objectives and options that may be assigned?

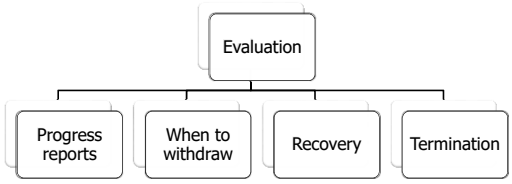
7–111

Learning Objective 4

Identify processes for evaluating progress.

7–112

Evaluation is conducted throughout the incident and continues until termination.



7–113

An effective IAP should lead to favorable progress reports and incident stabilization.

As new information becomes available and circumstances change

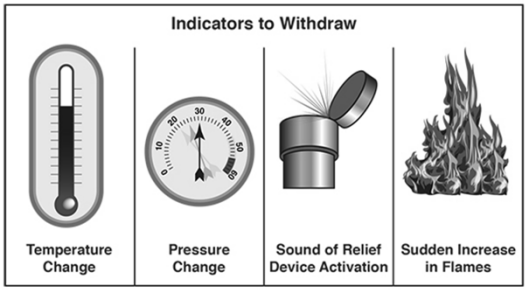
IC should also reevaluate IAP

If initial plan is not working, it must be changed

First responders should communicate the status of the planned response and the progress of their actions to the IC

7–114

It may become necessary to withdraw.



7–115

Normally, the last strategic goals at a hazardous materials emergency are recovery and termination efforts.

Recovery	• Returning the incident scene and responders to a preincident level of readiness
Termination	• Documenting the incident and using this information to evaluate the response

7–116

Recovery has three major goals.

Return the operational area to a safe condition

Debrief personnel before they leave the scene

Return the equipment and personnel of all involved agencies to the condition they were in before the incident

7–117

On-scene recovery efforts aim to return the scene to a safe condition.

Generally, fire and emergency services organizations do not conduct remedial cleanup actions

Unless those actions are absolutely necessary to eliminate conditions that present an imminent threat to public health and safety

7–118

On-scene debriefing, conducted in the form of a group discussion, gathers information from all operating personnel.

During the debriefing stage, responders should obtain information regarding

- Important observations
- Actions taken
- Timeline of those actions

7–119

OSHA requires that responders receive certain information before leaving the scene.

- Identity of material involved
- Potential adverse effects of exposure to the material
- Actions to be taken for further decontamination
- Signs and symptoms of an exposure
- Mechanism by which a responder can obtain medical evaluation and treatment
- Exposure documentation procedures

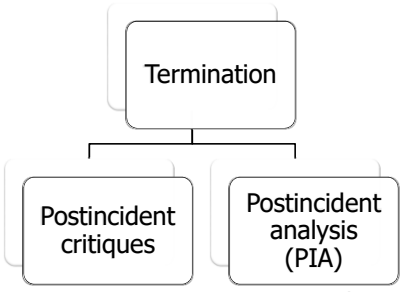
7–120

Operational recovery involves actions necessary to return resource forces to preincident readiness.

- Release of units
- Resupply of materials and equipment
- Decontamination of equipment and PPE
- Preliminary actions necessary for obtaining financial restitution

7–121

The termination phase involves two procedural actions.



7–122

The postincident critique is intended to identify operational deficiencies and learn from mistakes.

Critiques

- Need to occur as soon as possible after the incident
- Involve all responders, including law enforcement, public works, and EMS responders
- List individuals in attendance
- Note any operational deficiencies that were identified

7–123

The postincident analysis process compiles information and makes recommendations for improvements.

- Operational weaknesses
- Training needs
- Necessary procedural changes
- Required additional resources
- Necessary updates and/or required changes

7–124

The postincident analysis includes additional information.

- Completion of necessary reporting procedures required to document personal exposures
- Equipment exposures
- Incident reports
- Staff analysis reports
- Change or improvement benchmarked for further consideration
- Follow-up analysis or training

7–125

REVIEW QUESTION

Explain how incident recovery and incident termination can aid in incident evaluation.

Chapter 7: Implementing and Evaluating the Action Plan: Incident Management and Response Objectives and Options

Key Terms

1. **Incident Management System (IMS)** – System described in NFPA® 1561, *Standard on Emergency Services Incident Management System*, that defines the roles, responsibilities, and standard operating procedures used to manage emergency operations. Such systems may also be referred to as Incident Command Systems (ICS).
2. **Safety Officer** – Member of the IMS command staff responsible to the Incident Commander for monitoring and assessing hazardous and unsafe conditions and developing measures for assessing personnel safety on an incident. *Also known as* Incident Safety Officer.
3. **Memorandum of Understanding (MOU)** – Form of written agreement created by a coalition to make sure that each member is aware of the importance of his or her participation and cooperation.
4. **Hazard-Control Zones** – System of barriers surrounding designated areas at emergency scenes, intended to limit the number of persons exposed to a hazard and to facilitate its mitigation. A major incident has three zones: Restricted (Hot) Zone, Limited Access (Warm) Zone, and Support (Cold) Zone. EPA/OSHA term: Site Work Zones. *Also known as* Control Zones and Scene Control Zones.
5. **Hot Zone** – Potentially hazardous area immediately surrounding the incident site; requires appropriate protective clothing and equipment and other safety precautions for entry. Typically limited to technician-level personnel. *Also known as* Exclusion Zone.
6. **Warm Zone** – Area between the hot and cold zones that usually contains the decontamination corridor; typically requires a lesser degree of personal protective equipment than the Hot Zone. *Also known as* Contamination Reduction Zone *or* Contamination Reduction Corridor.
7. **Cold Zone** – Safe area outside of the warm zone where equipment and personnel are not expected to become contaminated and special protective clothing is not required; the Incident Command Post and other support functions are typically located in this zone. *Also known as* Support Zone.
8. **Staging Area** – Prearranged, temporary strategic location, away from the emergency scene, where units assemble and wait until they are assigned a position on the emergency scene; these resources (personnel, apparatus, tools, and equipment) must then be able to respond within three minutes of being assigned. Staging Area Managers report to the Incident Commander or Operations Section Chief, if one has been established.
9. **Evidence** – Information collected and analyzed by an investigator.
10. **Postincident Critique** – Discussion of the incident during the Termination phase of response. Discussion includes responders, stakeholders, and command staff, to determine facets of the response that were successful and areas that can be improved upon.
11. **Postincident Analysis (PIA)** – Overview and critique of an incident including feedback from members of all responding agencies. Typically takes place within two weeks of the incident. In the training environment it may be used to evaluate student and instructor performance during a training evolution.

True/False

1. False
2. True
3. True
4. False
5. True
6. True
7. True
8. False
9. False
10. False

Fill in the Blank

1. warm
2. shielding
3. size, people
4. property
5. life
6. postincident analysis

Picture Identification

Part I: Implementing Response Objectives and Action Options
1. Cornering/quartering staging

Part II: Evaluating Progress
1. Withdrawal

Matching

Part I: Hazard Control Zones
1. A
2. C
3. B
4. C
5. B
6. A

Part II: NIMS-ICS Organizational Functions
1. A
2. F
3. H
4. E
5. C
6. D
7. G
8. B
9. I

Multiple Choice

1. C
2. D
3. C
4. C
5. D
6. D

7. C
8. D
9. B
10. B

Short Answer

1. *Answers may vary; students should include two of the following.*
   Weapons of Mass Destruction-Civil Support Teams (WMD-CST)
   Disaster Medical Assistance Teams (DMAT)
   Disaster Mortuary Operational Response Teams (DMORT)
   National Medical Response Team- Weapons of Mass Destruction (NMRT-WMD)
   National Guard Chemical, Biological, Radiological, Nuclear and High Yield Explosive (CBRNE) Enhanced Response Force Package (CERFP)
   Urban Search and Rescue (US&R) Task Forces
   Incident Management Teams (IMT)
2. *Answers may vary; students should include at least three of the following.*
   The former IC must announce the change to avoid any possible confusion caused by others hearing a different voice acknowledging messages and issuing orders.
   The person relinquishing Command must provide the person assuming Command with as clear of a picture of the situation as possible (provide a briefing or situation status report).
   The person assuming Command acknowledges receipt of briefing information by repeating it back to current IC
3. *Answers may vary; students should include one of the following.*
   It spreads out emergency response personnel from one another to limit their exposure as a target and minimizes the effects of a secondary type of attack/device
   Allows personnel to envelop the scene and provide multiple treatment areas or operation
4. Answers
   Procedure for checking in at the scene
   Way of identifying and tracking the location of each unit and all personnel on scene
   Procedure for releasing people, equipment, and apparatus that are no longer needed
5. *Answers may vary; students should include four of the following.*
   Do not touch anything unless it is necessary.
   Avoid disturbing areas not directly involved in rescue activities.
   Remember what the scene looked like at arrival and as the incident progressed.
   Document observations.
   Take photographs and videos of the scene.
   Remember and document when something was moved or touched.
   Minimize the number of people working in the area.
   Leave fatalities and their surroundings undisturbed.
   Isolate and secure areas where evidence is found and report it to law enforcement.
   Identify victims, witnesses, and the presence of evidence.
   Preserve potentially transient physical evidence.
   Have evidence collection points located near the decontamination corridor and hot zone exits to gather evidence during decon or doffing operations.
   Follow predetermined procedures regarding operations at crime scenes.

Hazardous Materials for First Responders Fifth Edition

Chapter 8 — Implementing the Response: Terrorist Attacks, Criminal Activities and Disasters

HAZARDOUS MATERIALS FOR FIRST RESPONDERS
FIFTH EDITION

IFSTA

Learning Objective 1

Define terrorism.

8–1

Terrorist deliberately target locations where civilians are present.

- All societies are vulnerable to incidents involving terrorism
- Countries in conflict are especially vulnerable
- The U.S. Federal Bureau of Investigation (FBI) heads U.S. government agencies in investigating and attempting to prevent terrorist attacks on U.S. soil

8–2

There are many definitions of terrorism.

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

8–3

Under the FBI definition of terrorism, all terrorist activities share three commitments.

1. Using force that involves illegal activities
2. Intimidation or coercion
3. Supporting political or social objectives

8–4

Terrorism may also be defined as the unlawful or threatened use of force or violence.

The decision to engage in criminal, intimidating activities to achieve goals separates a terrorist organization from a legitimate organization

Any organization, legitimate or not, can resort to terrorist means to achieve its political or social agenda

Terrorists can operate as a group or act alone

8–5

Terrorist organizations plan activities that will have an emotional effect on the target population.

Terrorism is designed to cause	• Disruption • Fear • Panic
Terrorists may want to	• Draw attention to their cause • Coerce or intimidate governments into granting their demands • Provoke governments into repressive actions

8–6

Terrorists will attack anywhere they detect vulnerability — on land, in the air, or at sea.

Courtesy of the U.S. Department of Defense

8–7

REVIEW QUESTION

How is a terrorist organization different from a legitimate organization?

8–8

Learning Objective 2

Explain ways of identifying terrorist attacks.

8–9

Terrorist incidents have many similarities to non-terrorist incidents.

- Same incident priorities
- Same Incident Management System
- Same risk-based response procedures

8–10

Terrorist incidents are targeted.

Intent	• Intended to cause damage, inflict harm, and kill • Specifically targets public and/or first responders
Severity and Complexity	• May involve large numbers of casualties, large areas, and other significant dangers
Crime Scene Management	• Responders must preserve evidence and notify law enforcement
Command Structure	• Unified Command Structure is required at most terrorist incidents • Law enforcement will have jurisdiction

8–11

Terrorist attack incident scenes may be very dangerous to responders.

Courtesy of FEMA News Photos; photo by Mike Rieger

Responders must recognize potential evidence and avoid disturbing it if possible.

Courtesy of the U.S. Navy; photo by Journalist 1st Class Mark D. Faram

Some situations can cue the responder to consider the possibility of a terrorist attack.

Report of two or more medical emergencies in a public location
Unusually large number of people with similar medical signs and symptoms at physicians' offices or medical emergency rooms
Reported explosion at a public place, government building, or a location with historical or symbolic significance

CBRNE attacks each have their own unique indicators.

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

REVIEW QUESTION

What are some of the cues that should prompt consideration of a terrorist attack?

Learning Objective 3

Describe the range of tactics that may be used in a terrorist attack.

Terrorist use a range of tactics.

- Traditional
  - Assassination
  - Armed assault
  - Bombings and suicide bombings
- Weapons of Mass Destruction
- Cyber terrorism
- Agroterrorism

8–18

Terrorists are likely to target locations where an attack has the potential to do the greatest harm.

- Killing or injuring persons
- Causing panic and/or disruption
- Damaging the economy
- Destroying property
- Demoralizing the community

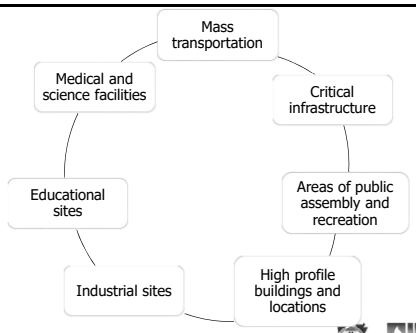
8–19

Any location or occupancy that has large public gatherings or some significance might become a target.

Places with large public gatherings	• Football stadiums • Sports arenas • Theaters • Shopping malls
Places with historical, economic, or symbolic significance	• Local monuments • High-profile buildings • High-traffic bridges

8–20

Terrorist may target significant places.



8–21

Experts fear that terrorists have the means to broaden their tactics to include the use of WMD.

According to the U.S. Government a Weapon of Mass Destruction is

Any weapon or device that is intended to or has the capability to cause death or serious bodily injury to a significant number of people through the release, dissemination, or impact of one of the following means

Toxic or poisonous chemicals	A disease organism	Radiation or radioactivity

8–22

Many WMDs are difficult to successfully deploy.

Potential WMDs may be

- Difficult to store
- Used very quickly
- Necessary to keep in temperature-controlled environments

8–23

Producing sophisticated weapons requires a high level of resources and knowledge.

- The greatest threat of mass-produced WMD agents comes from
- Nations or organizations with the infrastructure, finances, and scientific knowledge to produce them
- **NOT** from isolated terrorist groups

8–24

The toxin ricin can be made from recipes available on the Internet.

8–25

Some WMDs are relatively readily produced and/or acquired.

Ricin	• Biological toxin made from castor beans • Recipes are available on the Internet
Triacetone triperoxide (TATP)	• Explosive that can be made from common household products without expensive laboratory equipment
Foot-and-mouth disease	• Biological agricultural threats that have natural reservoirs in nature
Radiological materials	• Materials can be stolen and/or acquired from a variety of accessible medical and construction sources
Toxic industrial chemicals	• Chemicals are available in every jurisdiction

8–26

Consensus has not been reached on which types of WMDs first responders are most likely to encounter.

Given the availability of parts, relative ease of production, and ease of deployment, the following list is a probable WMD threat spectrum from most likely to least likely

- Explosives
- Biological toxins
- Industrial chemicals
- Biological pathogens
- Radiological materials
- Military-grade chemical weapons
- Nuclear weapons

8–27

Explosives are more commonly used than other WMDs.

8–28

NOTE

Conventional attacks such as hijackings, sniper attacks, and/or shootings are also highly likely, but not considered a WMD threat for purposes of this list.

8–29

The use of secondary devices at terrorist attacks or illicit laboratories is always a possibility.

Secondary devices

- Often designed to affect an ongoing emergency response
- Create more chaos and injure responders and bystanders
- May also be deployed as a diversionary tactic to route emergency responders away from the primary attack area
- Will be hidden or camouflaged

8–30

Booby traps, like this acid jar, might be set to protect illicit labs.

Booby traps may use

- Other weapons
- Chemical, biological, or radiological materials
- Animals such as snakes or guard dogs

8–31

Secondary devices are usually explosives of some kind.

Secondary devices may also be deployed as a diversionary tactic to route emergency responders away from the primary attack area

Secondary devices will be hidden or camouflaged

8–32

Secondary devices and booby traps can be disguised and/or hidden.

Booby traps and secondary devices may be concealed. Therefore, responders should look for things that seem out of place, like this wire leading under the floor mat.

8–33

CAUTION

If one device has been found or detonated, always expect another.

8–34

Guidelines can help protect against secondary devices.

- Anticipate the presence of a secondary device at any suspicious incident
- Conduct a visual search for a secondary device (or anything suspicious) before moving into the incident area
- Limit numbers of emergency response personnel to those performing critical tasks (rescue) until the area has been checked and confirmed that no additional devices are present
- Avoid touching or moving anything that may conceal an explosive device (including items such as backpacks and purses)
- Manage the scene with cordons, boundaries, and scene control zones
- Evacuate victims and nonessential personnel as quickly as possible
- Preserve the scene as much as possible for evidence collection and crime investigation

8–35

WARNING

NEVER approach or move suspicious objects. Notify appropriate personnel (law enforcement/Explosive Ordnance Disposal/bomb squad personnel) and evacuate the area immediately.

8–36

Be cautious of any items that arouses curiosity.

- Containers with unknown liquids or materials
- Unusual devices or containers with electronic components
- Devices containing quantities of fuses, fireworks, match heads, black powder, smokeless powder, incendiary or other unusual materials
- Materials, such as nails, bolts, drill bits, and marbles, attached to or surrounding an item that could be used for shrapnel
- Ordnance such as blasting caps, detonation cord, military explosives, commercial explosives, and grenades
- Devices, such as razor blades and trip wires, on containers or other items on handles, valves, ladders, or other locations
- Energized bare electrical wiring or exposed metal surfaces connected to an electrical system
- Any combination of the previously described items

8–37

This replica shows the nuts and broken glass used as shrapnel in a guitar IED detonated in Israel.

8–38

REVIEW QUESTIONS

What types of places are terrorists likely to target?

What types of WMDs may be readily available or easily made?

What should you do if you suspect a booby trap or secondary device?

8–39

Learning Objective 4

Identify indicators and types of explosive attacks and devices.

8–40

The majority of terrorist attacks involve the use of explosive materials and incendiary devices.

Courtesy of the U.S. Department of Defense

8–41

Know the indicators of explosive/ incendiary attacks.

- Warning or threat of an attack or received intelligence
- Reports of an explosion
- Explosion
- Accelerant odors
- Multiple fires or explosions
- Incendiary device or bomb components
- Unexpectedly heavy burning or high temperatures
- Unusually fast burning fires

(Cont.)

8–42

Know the indicators of explosive/ incendiary attacks.

- Unusually colored smoke or flames
- Presence of propane or other flammable gas cylinders in unusual locations
- Unattended packages, backpacks, or objects left in high traffic/public areas
- Fragmentation damage/injury
- Damage that exceeds the level usually seen during gas explosions
- Crater(s)
- Scattering of small metal objects

8–43

Car and truck bombs can do greater damage than accidental gas explosions.

Courtesy of the U.S. Air Force; photo by Senior Airman Sean Worrell

8–44

An explosive material will undergo an extremely fast, self-propagating reaction when subjected to energy.

8–45

Explosive materials react when they combine an oxidizing component with a fuel component.

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 compresses the surrounding atmosphere into a shock
- The pressure wave formed can demolish almost anything in its path

8–46

Both phases of a blast-pressure wave cause damage.

Positive-pressure phase

- Shock front leads, striking anything in its path with a hammering force
- Continues outwards in expanding radius until energy diminishes
- Energy dissipates due to distance or because it transfers to objects in path

Negative-pressure phase

- Displaced atmosphere rushes back in to fill the vacuum left at the center of explosion
- Structures damaged in the initial blast can be further damaged in negative-pressure phase
- Lasts about three times longer than the positive-pressure phase

8–47

Multiple components of explosions cause destruction.

- Blast pressure phase
- Rapid release of energy may throw debris and shrapnel outwards
- Shock wave may travel through ground, creating seismic disturbance
- Explosion may release thermal heat energy in the form of a fireball

The quantity and type of explosives determine the size of an explosion.

The hot zone may be limited to a small area or it could extend for blocks

An explosion can also create secondary hazards from breaking glass and any degree of structural collapse

In general, high explosives create a larger effect, in sound and size, than low explosives.

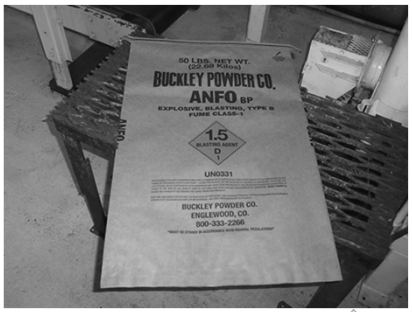
High explosives

- Decompose rapidly (almost instantaneously) in detonation that can include velocities faster than the speed of sound
- Placarded as DOT Division Number 1.1
- Examples of high explosives available for legal purchase
  - Plastic explosives, such as C4 and C3
  - Nitroglycerin
  - TNT
  - Blasting caps
  - Dynamite
  - Ammonium nitrate and fuel oil (ANFO) and other blasting agents

C3 is a plastic explosive.

TNT detonates faster than the speed of sound.

ANFO can be purchased legally.



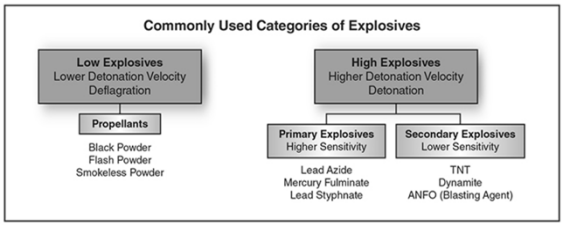
Courtesy of David Alexander, Texas Commission on Fire Protection

Low explosive materials deflagrate at a speed slower than the speed of sound.

Low explosives

- Decompose rapidly but do not produce an explosive effect unless they are confined
- Placarded as DOT Division Number 1.4
- Examples
  - Black powder
  - Pyrotechnic substances used in fireworks and road flares

Primary explosives are high explosives and are more sensitive than secondary explosives.



Primary explosives are easily initiated.

Primary explosives

- Highly sensitive to heat
- Usually used as detonators
- Small amounts, even a single grain or crystal, can detonate
- Examples
  - Lead azide
  - Mercury fulminate
  - Lead styphnate

Secondary explosives are less sensitive than primary explosives.

Secondary explosives

- Designed to detonate only under specific circumstances — usually by activation energy from a primary explosive
- Less sensitive than primary explosives to initiating stimuli, such as heat or flame
- Example - TNT

Tertiary explosives are also called blasting agents.

Tertiary explosives

- Insensitive materials based on ammonium nitrate (AN)
- Usually require initiation from a secondary explosive
- Not all experts recognize this category — Some would consider blasting agents to be secondary explosives

Terrorists may use commercial and military explosives that are normally used for legitimate purposes.

Terrorists may use military munitions in explosive attacks.

Mortars	Grenades	Antipersonnel mines
Surface-to-air missiles	Rocket propelled grenades	Other types of military explosives

8–60

Nonmilitary first responders are more likely to encounter homemade or improvised explosive materials.

- Responders typically stage 300 meters (1 000 feet) away from a suspected explosive material incident
- Improvised explosive materials are typically made by combining an oxidizer with a fuel
- Many fairly simple to make, require very little technical expertise or specialized equipment
- Materials created are often highly unstable

8–61

Most homemade explosives are made by combining an oxidizer with a fuel.

8–62

NOTE

Page 374 of the 2016 *Emergency Response Guidebook* provides an IED Safe Stand-Off Distance table.

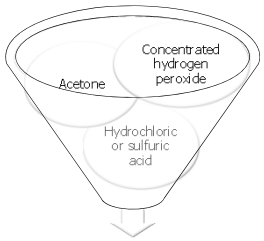
8–63

WARNING

Never handle commercial or military explosives.

8–64

Peroxide-based explosives are made with concentrated hydrogen peroxide.



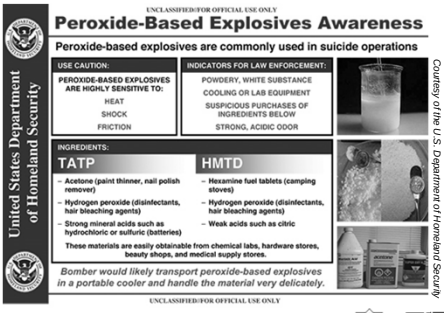
Peroxide-based explosives

8–65

TATP (triacetonetriperoxide), a peroxide-based explosive, may be very unstable.

8–66

Peroxide-based explosives labs may have quantities of acetone and hydrogen peroxide.



Courtesy of the U.S. Department of Homeland Security

8–67

Improvised Explosive Devices (IEDs) may contain chlorate-based oxidizers.

Chlorate-based oxidizers commonly take the form of a white crystal or powder that must be mixed with a fuel source

Chlorates are a common ingredient in some fireworks and can be purchased in bulk from fireworks and chemical supply houses

Many manufacturing processes and many products use chlorates

8–68

Some IEDs may contain nitrate-based oxidizers.

Courtesy of Texas Commission on Fire Protection

Nitrates are commonly found in ammonium nitrate, and fertilizers

8–69

Improvised explosive devices (IEDs) are relatively easy to make.

- Can be constructed in almost any location or setting
- Not commercially manufactured; they are homemade
- Usually constructed for a specific target
- Can be contained within almost any object

8–70

IEDs can be concealed as almost anything.

8–71

Sophisticated IEDs may be constructed with components scavenged from everyday items.

Courtesy of the U.S. Army; photo by Spc. Ben Brody

8–72

IEDs often contain items that will cause additional shrapnel damage and fragmentation injuries.

- Nails
- Tacks
- Broken glass
- Bolts

8–73

IEDs are difficult to identify because they can look like anything.

The bomber's imagination is the only limitation to the design and implementation of IEDs

Be cautious of any items that attract attention because they seem out of place, anomalous, out of the ordinary, curious, suspicious, out of context, or unusual

8–74

WARNING

An IED can look like ANYTHING!

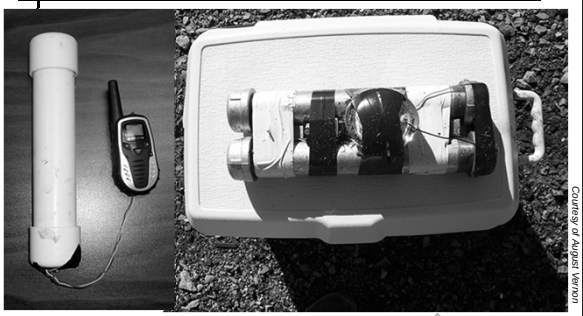
8–75

IEDs are typically categorized by their container and the way in which they are initiated.

- Pipe bombs
- Satchel, backpack, knapsack, duffle bag, briefcase, or box bombs
- Plastic bottle bombs
- Fireworks
- M-Devices
- Carbon Dioxide (CO_2) Grenades
- Tennis ball bombs
- Other existing objects

8–76

Steel or PVC pipes can be used to make pipe bombs.



Courtesy of Angus Verdun

8–77

Bombs can be concealed in satchels, backpacks, knapsacks, duffle bags, or briefcases.

Courtesy of August Vernon

8–78

Plastic bottle bombs contain reactive materials that will expand rapidly, causing the container to explode.

- 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 bombs
- Once initiated, they can detonate at any time

8–79

Be familiar with M-Devices and (CO_2) Grenades.

M-Devices	Carbon Dioxide (CO_2) Grenades (crickets)
• Constructed of cardboard tubes (often red) • Filled with flash powder • Sealed at both ends • Ignited by fuses	• Made by drilling a hole in used CO_2 containers and filling with an explosive powder • Usually initiated by a fuse • Shrapnel may be added to the outside of the container • Small range but will create great deal of destruction

8–80

Bombs can be concealed in ordinary items.

Courtesy of August Vernon

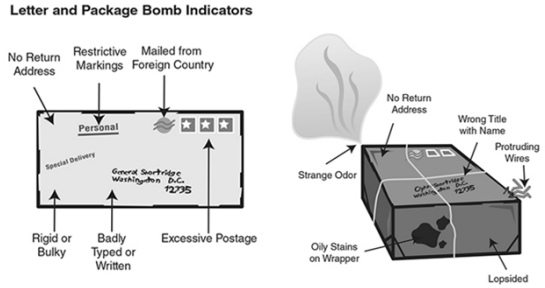
8–81

WARNING

Do not move, handle, or disturb an IED when found!

8–82

A package or letter may be used to conceal the explosive device or material.



8–83

Terrorists may carry PBIEDs or they may be attached to coerced or unwilling victims.

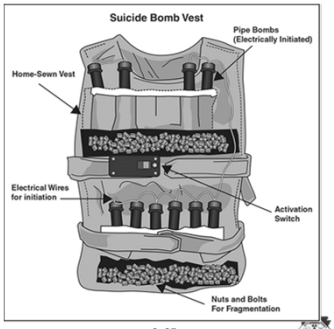
PBIED

Person-Borne Improvised Explosive Device

Courtesy of August Vernon

8–84

Clothing, such as a suicide vest, can conceal a bomb.



8–85

Know behavioral indicators of potential suicide bombers.

- Fear, nervousness, or overenthusiasm
- Profuse sweating
- Keeping hands in pockets
- Repeated or nervous touching or patting of clothing
- Slow-paced walking while constantly shifting eyes to the left and right
- Major attempts to avoid security personnel

(Cont.)

8–86

Know behavioral indicators of potential suicide bombers.

- Obvious or awkward attempts to blend in with a crowd
- Obvious disguising of appearance
- Actions indicating a strong determination to get to a target
- Repeated visits to a high-risk location during the recon/ target acquisition phase
- Placing items in locations that seem out of place or arouse curiosity

8–87

If a suicide bomber is suspected, clear and isolate the area and let EOD personnel handle the first approach.

Courtesy of the U.S. Marine Corps; photo by Sgt. Lukas M. Atwell

8–88

VBIEDs can cause massive destruction.

Courtesy of the U.S. Air Force; photo by Master Sgt. Robert H. Hargreaves Jr.

8–89

VBIEDs can be placed anywhere in a vehicle.

VBIEDs

Vehicle-Borne Improvised Explosive Devices

- May contain many thousands of pounds (kilograms) of explosives
- Explosives are often concealed in trunk

8–90

Know the indicators of a possible VBIED attack.

- Preincident intelligence or 9-1-1 calls leading to the suspected vehicle
- Vehicle parked suspiciously for a prolonged amount of time in a strategic or central location
- Vehicle abandoned in a public assembly, tourist area, pedestrian area, retail area, or transit facility
- Vehicle parked between, against, or close to the columns of a multistory building
- Vehicle that appears to be weighted down or sits unusually low on its suspension
- Vehicle with stolen plates, nonmatching plates, or no plates at all

(Cont.)

8–91

Know the indicators of a possible VBIED attack.

- Wires, bundles, electronic components, packages, unusual containers, liquids or materials visible in the vehicle
- Unknown liquids or materials leaking under vehicle
- Unusually screwed, riveted, or welded sections located on the vehicle's bodywork
- Unusually large battery or extra battery found under the hood or elsewhere in the vehicle
- Blackened windows or covered windows

(Cont.)

8–92

Know the indicators of a possible VBIED attack.

- Taped, sealed, or otherwise inaccessible hollows of front or rear bumpers
- Tires that seem solid, instead of air-inflated
- Bright chemical stains or unusual rust patches on a new vehicle
- Chemical odor present or unusual chemical leak beneath vehicle
- Wiring protruding from the vehicle, especially from trunk or engine compartment

(Cont.)

8–93

Know the indicators of a possible VBIED attack.

- Wires or cables running from the engine compartment, through passenger compartment, to the rear of vehicle
- Wires or cables leading to a switch behind sun visor
- Appearance or character of the driver does not match the use or type of vehicle
- Driver seems agitated, lost, and unfamiliar with vehicle controls
- Anything about a vehicle that seems out of place, unusual, abnormal, or arouses curiosity

8–94

WARNING

Never approach a suspicious vehicle once an indicator of possible VBIED has been noticed.

8–95

Response to explosive/IED events must be conducted within an Incident Command System.

- Follow designated SOP/Gs
- ALWAYS proceed with caution, especially if an explosion has occurred or it is suspected that explosives may be involved in an incident
- Understand that secondary devices may be involved
- Request EOD (bomb squad) personnel, hazmat, and other specialized personnel as needed
- Treat the incident scene as a crime scene until proven otherwise

8–96

Only certified EOD technicians should touch, move, defuse, or otherwise handle explosive devices.

Courtesy of the U.S. Air Force; photo by Airman Matthew Flynn

8–97

Know appropriate responses to explosive/IED events.

- NEVER touch or handle a suspected device, even if someone else already has
- Do not use two-way radios, cell phones, or mobile data terminals (MDT) within a minimum of 300 feet (90 m) of any device or suspected device
- Use intrinsically safe communications equipment within the isolation zone
- Note unusual activities or persons at the scene and report observations to law enforcement
- Limit personnel exposure until the risk of secondary devices is eliminated

8–98

WARNING

Avoid staging near gardens, garbage bins, or other vehicles that could conceal explosive or incendiary devices. Limit exposure until the secondary device risk is eliminated.

8–99

REVIEW QUESTIONS

What type of explosive are nonmilitary first responders most likely to encounter?

What are indicators of an explosive attack?

8–100

Learning Objective 5

Identify indicators and types of chemical attacks.

8–101

A chemical attack is the deliberate release of a toxic that can poison people and the environment.

Chemical agents

- Intended for use in warfare or terrorist activities to kill, seriously injure, or seriously incapacitate people through their physiological effects

Toxic industrial materials (TIMs)

- Particularly poisonous hazardous materials that are normally used for industrial purposes
- Could be used by terrorists to deliberately kill, injure, or incapacitate people

8–102

Table 8.3 provides the UN/DOT identification number and hazard class for some common chemical warfare agents.

Table 8.3
UN/DOT ID Number, Hazard Class, and *ERG* Guide Number for Selected Chemical Agents

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 (GD)	2810	6.1	153	(GD)
V Agent (VX)	2810	6.1	153	VX
Blister Agents/Vesicants				
Mustard (H)	2810	6.1	153	H
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 (CR)	1693	6.1	159	
Mace (CN)	1697	6.1	153	
Pepper Spray (OC)		2.2 /6.1*	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.

NOTE: Letters in parentheses next to the name represent military designations, not chemical formulas

8–103

Chemical attacks usually result in readily observable features that develop very rapidly.

Chemical attack indicators include

- Warning or threat of an attack or received intelligence
- Presence of hazardous materials or laboratory 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 or tastes that are out of character with the surroundings
- Multiple individuals exhibiting unexplained skin, eye, or airway irritation

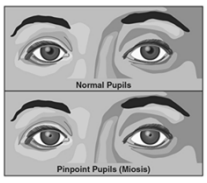
8–104

Know chemical attack indicators.

- Unexplained bomb or munition-like material, especially if it contains a liquid
- Unexplained vapor clouds, mists, and plumes
- Multiple individuals exhibiting unexplained health problems
- Unexplained deaths and/or mass casualties
- Casualties distributed downwind (outdoors) or near ventilation systems (indoors)
- Multiple individuals experiencing blisters and/or rashes

8–105

Exposure to chemical agents may cause miosis (pinpoint pupils).



8–106

Like this acid release, chemical agents may kill or wither trees and vegetation.

Courtesy of Barry Lindley

8–107

Be alert for chemical attack indicators.

- Trees, shrubs, bushes, food crops, and/ or lawns that are dead, discolored, abnormal in appearance, or withered (not under drought conditions)
- Surfaces exhibiting oily droplets or films and unexplained oily film on water surfaces
- Abnormal number of sick or dead birds, animals, and/or fish
- Unusual security, locks, bars on windows, covered windows, and barbed-wire enclosures

8–108

TIMs used as chemical weapons may be identified through traditional methods.

- Identification of occupancy types and locations
- Container shapes
- Hazardous materials placards, labels, and markings
- Written resources
- Sensory indicators
- Use of monitoring and detection devices

8–109

Nerve agents are the most toxic chemical warfare agents.

Nerve agents

- Exposure to even minute quantities can kill quickly by attacking the nervous system
- Stable, easily dispersed, and highly toxic
- Rapid effects when absorbed through the skin or respiratory system
- Liquids at ambient temperatures
- Dispersed as an aerosolized liquid (vapor, not gas)

8–110

WARNING

Odor is not a safe indicator of a hazard.

8–111

First responders should be familiar with several nerve agents.

Tabun (GA)	• Usually low volatility, persistent chemical agent • Absorbed through skin contact or inhaled as a vapor
Sarin (GB)	• Usually volatile, nonpersistent chemical agent • Mainly inhaled
Soman (GD)	• Usually moderately volatile chemical agent • Can be inhaled or absorbed through skin contact
Cyclohexyl sarin (GF)	• Low-volatility persistent chemical agent • Absorbed through skin contact and inhaled as a vapor
V-agent (VX)	• Low-volatility persistent chemical agent • Usually absorbed through the skin but can be inhaled

8–112

Nerve agents' volatilities vary widely.

- G-series agents tend to be nonpersistent unless thickened with some other agent to increase persistency
- GB is an easily volatile liquid that is primarily an inhalation hazard
- The volatilities of GD, GA, and GF are between those of GB and VX, and their vapors are heavier than air

8–113

Table 8.4 provides information about nerve agents including descriptions and symptoms of exposure.

Table 8.4
Nerve Agent Characteristics

Nerve Agent (Symbol)	Descriptions	Symptoms (All Listed Agents)
Tabun (GA)	• Clear, colorless, and tasteless liquid • May have a slight fruit odor, but this feature cannot be relied upon to provide sufficient warning against toxic exposure • **Probable Dispersion Method:** Aerosolized liquid	***Low or moderate dose by inhalation, ingestion (swallowing), or skin absorption:*** Persons may experience some or all of the following symptoms within seconds to hours of exposure: • Runny nose • Watery eyes • Small, pinpoint pupils • Eye pain • Blurred vision • Drooling and excessive sweating • Cough • Chest tightness • Rapid breathing • Diarrhea • Increased urination • Confusion • Drowsiness • Weakness • Headache • Nausea, vomiting, and/or abdominal pain • Slow or fast heart rate • Abnormally low or high blood pressure **Skin contact:** Even a tiny drop of nerve agent on the skin can cause sweating and muscle twitching where the agent touched the skin ***Large dose by any route:*** These additional health effects may result: • Loss of consciousness • Convulsions • Paralysis • Respiratory failure possibly leading to death ***Recovery Expectations:*** • Mild or moderately exposed people usually recover completely • Severely exposed people are not likely to survive • Unlike some organophosphate pesticides, nerve agents have not been associated with neurological problems lasting more than 1 to 2 weeks after the exposure
Sarin (GB)	• Clear, colorless, tasteless, and odorless liquid in pure form • **Probable Dispersion Method:** Aerosolized liquid	
Soman (GD)	• Pure liquid is clear, colorless, and tasteless; discolors with aging to dark brown • May have a slight fruity or camphor odor, but this feature cannot be relied upon to provide sufficient warning against toxic exposure • **Probable Dispersion Method:** Aerosolized liquid	
Cyclohexyl sarin (GF)	• Clear, colorless, tasteless, and odorless liquid in pure form • Only slightly soluble in water • **Probable Dispersion Method:** Aerosolized liquid	
V-Agent (VX)	• Clear, amber-colored odorless, oily liquid • Miscible with water and dissolves in all solvents • Least volatile nerve agent • Very slow to evaporate (about as slowly as motor oil) • Primarily a liquid exposure hazard, but if heated to very high temperatures, it can turn into small amounts of vapor (gas) • **Probable Dispersion Method:** Aerosolized liquid	

Source: Information on symptoms provided by the Centers for Disease Control and Prevention (CDC).

8–114

The most effective treatment for chemical agent exposure are autoinjectors containing antidotes.

8–115

Blister agents (vesicants) burn and blister the skin or any other part of the body they contact.

- Act on eyes, mucous membranes, lungs, skin, blood-forming organs
- Damage respiratory tract when inhaled
- Can cause vomiting and diarrhea when ingested
- More likely to produce casualties than fatalities
- Usually persistent
- May be oily liquids
- Difficult to remove during decontamination

8–116

Blister agents can be categorized into 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) (a mixture of lewisite [L] and distilled mustard [HD]) • Phenyldichloroarsine (PD)
Halogenated oximes	• Phosgene oxime (CX)

* More information about blister agents can be found in Table 8.5

8–117

Blood agents are chemical asphyxiants.

Interfere with body's ability to use oxygen

- Prevent red blood cells from carrying oxygen to other cells in the body
- Inhibit ability of cells to use oxygen for producing energy required for metabolism

8–118

Arsine gas is formed when arsenic comes in contact with an acid.

Table 8.6
Arsine (SA)

Description	Symptoms
• Colorless, nonirritating toxic gas with a mild garlic odor that is detected only at levels higher than those necessary to cause poisoning • Is formed when arsenic comes in contact with an acid • **Probable Dispersion Method:** Vapor release	**Low or moderate dose by inhalation:** Persons may experience some or all of the following symptoms within 2 to 24 hours of exposure: • Weakness • Headache • Confusion • Rapid breathing • red or dark urine • muscle cramps • Fatigue • Drowsiness • Shortness of breath • Nausea, vomiting, and/or abdominal pain • Yellow skin and eyes (jaundice) **Large dose by any route:** These additional health effects may result: • Loss of consciousness • Convulsions • Paralysis • Respiratory failure, possibly leading to death Other factors: • Showing these signs and symptoms does not necessarily mean that a person has been exposed. • If people survive the initial exposure, chronic effects may include: — Kidney damage — Numbness and pain in the extremities — Neuropsychological symptoms such as memory loss, confusion, and irritability

8–119

Hydrogen cyanide is a colorless, highly volatile liquid.

Table 8.7
Blood Agent Characteristics for AC and CK

Blood Agent (Symbol)	Description	Symptoms
Hydrogen cyanide (AC)	• Colorless gas or liquid • Characteristic *bitter almond* odor • Slightly lighter than air • Miscible • Extremely flammable • Explosive gas/air mixtures • Reacts violently with oxidants and hydrogen chloride in alcoholic mixtures, causing fire and explosion hazard • ***Probable Dispersion Method:*** Aerosolized liquid	May be absorbed through skin and eyes. Symptoms include: • ***Inhalation:*** Headache, dizziness, confusion, nausea, shortness of breath, convulsions, vomiting, weakness, anxiety, irregular heartbeat, tightness in the chest, and unconsciousness. Effects may be delayed. • ***Skin:*** May be absorbed. See *Inhalation* for other symptoms. • ***Eyes:*** Redness; vapor is absorbed. See *Inhalation* for other symptoms. • ***Ingestion:*** Burning sensation. See *Inhalation* for other symptoms.

Cyanogen chloride is a colorless, highly volatile liquid.

Cyanogen chloride (CK)	• Colorless gas • Pungent odor • Heavier than air • ***Probable Dispersion Method:*** Vapor release	Symptoms include: • ***Inhalation:*** Runny nose, sore throat, drowsiness, confusion, nausea, vomiting, cough, unconsciousness, edema with symptoms which may be delayed. • ***Skin:*** Readily absorbed through intact skin, causing systemic effects without irritant effects on the skin; frostbite may occur on contact with liquid; liquid may be absorbed; redness and pain. • ***Eyes:*** Frostbite on contact with liquid; redness, pain, and excess tears.

Source: *Information on symptoms provided by the Centers for Disease Control and Prevention (CDC).*

Choking agents attack and cause tissue damage to the lungs.

Choking agents

- Sometimes called *pulmonary* or *lung-damaging* agents
- Have industrial applications
- Responders may encounter them during normal hazmat incidents
- Include chemicals such as diphosgene (DP), chloropicin (PS), ammonia, hydrogen chloride, phosphine, and elemental phosphorus

Chlorine gas is usually pressurized and cooled to a liquid state for storage and transportation.

- Yellow-green in color
- Pungent, bleach-like, irritating odor
- When liquid chlorine released, quickly turns into a heavier than air gas
- Does not remain in its liquid form for long, so decon usually not required
- Exposure may cause coughing, chest tightness, burning eyes, nose, and throat, watering eyes, blurred vision, nausea and vomiting

Phosgene is a colorless, nonflammable gas that has the odor of freshly cut hay.

Odor threshold is well above its permissible exposure limit

→ Already at a harmful concentration by the time someone smells it

Phosgene may remain for long periods of time in trenches or other low-lying areas.

- Vapor density is much heavier than air
- Does not remain in its liquid form very long
- Decon is usually not required
- Exposure symptoms similar to chlorine
- May also cause burns and rash to skin

Riot control agents are sometimes called *tear gas* or *irritating agents.*

- Chemical compounds that cause immediate irritation to the eyes, mouth, throat, lungs, and skin, temporarily disabling people
- All are solids
- Require dispersion as aerosolized particles
- Some sold in small containers as personal defense devices
- Usually heavier than air (when dispersed)

The symptoms of exposure for all riot control agents are very similar.

Table 8.8
Riot Control Agent Characteristics

Riot Control Agent (Symbol)	Descriptions	Symptoms (All Listed Agents)
Chlorobenzylidene malononitrile (CS)	• White crystalline solid • Pepper-like smell	***Immediately after exposure:*** People exposed may experience some or all of the following symptoms: • ***Eyes:*** Excessive tearing, burning, blurred vision, and redness • ***Nose:*** Runny nose, burning, and swelling • ***Mouth:*** Burning, irritation, difficulty swallowing, and drooling • ***Lungs:*** Chest tightness, coughing, choking sensation, noisy breathing (wheezing), and shortness of breath • ***Skin:*** Burns and rash • ***Other:*** Nausea and vomiting Long-lasting exposure or exposure to a large dose, especially in a closed setting, may cause severe effects such as the following: • Blindness • Glaucoma (serious eye condition that can lead to blindness) • Immediate death due to severe chemical burns to the throat and lungs • Respiratory failure possibly resulting in death Prolonged exposure, especially in an enclosed area, may lead to long-term effects such as the following: • Eye problems including scarring, glaucoma, and cataracts • May possibly cause breathing problems such as asthma ***Recovery Expectations:*** If symptoms go away soon after a person is removed from exposure, long-term health effects are unlikely to occur.
Chloroacetophenone (CN, mace)	• Clear yellowish brown solid • Poorly soluble in water, but dissolves in organic solvents • White smoke smells like apple blossoms	
Oleoresin Capsicum (OC, pepper spray)	• Oily liquid, typically sold as a spray mist • ***Probable Dispersion Method:*** Aerosol	
Dibenzoxazepine (CR)	• Pale yellow crystalline solid • Pepper-like odor • ***Probable Dispersion Method:*** Propelled	
Chloropicrin (PS)	• Oily, colorless liquid • Intense odor • Violent decomposition when exposed to heat	

Source: Information on symptoms provided by the Centers for Disease Control and Prevention (CDC).

Incapacitants are sometimes categorized as riot control agents.

Incapacitant

- Produces a temporary disabling condition that persists for hours to days after exposure
- Examples of incapacitants include
  - Central nervous system (CNS) depressants (anticholinergics)
  - CNS stimulants (lysergic acid diethylamide or LSD)

Vomiting agents are sometimes categorized as riot control agents.

Vomiting agent

- Causes violent, uncontrollable sneezing, coughing, nausea, vomiting, and a general feeling of bodily discomfort
- Dispersed as an aerosol
- Produces its effects by inhalation or direct action on the eyes
- Principal vomiting agents include:
  - Diphenylchlorarsine (DA)
  - Diphenylaminearsine chloride (Adamsite or DM)
  - Diphenylcyanarsine (DC)

A toxic industrial material (TIM) is an industrial chemical.

- Toxic at a certain concentration
- Produced in quantities exceeding 30 tons (30.5 tonnes) per year at one production facility
- Not as lethal as highly toxic nerve agents
- Pose a far greater threat than chemical warfare agents because produced in very large quantities (multitons) and are readily available

Table 8.9 lists TIMs by Hazard Index Ranking.

Table 8.9
Toxic Industrial Materials Listed by Hazard Index Ranking

High Hazard	Medium Hazard	Low Hazard
Ammonia	Acetonitrile	Allyl isothiocyanate
Arsine	Acrolein	Arsenic trichloride
Boron trichloride	Acrylonitrile	Bromine
Boron trifluoride	Allyl alcohol	Bromine chloride
Carbon disulfide	Allylamine	Bromine pentafluoride
Chlorine	Allyl chloroformate	Bromine trifluoride
Chlorine	Boron tribromide	Carbonyl fluoride
Ethylene oxide	Carbon monoxide	Chlorine pentafluoride
Fluorine	Carbonyl sulfide	Chlorine trifluoride
Formaldehyde	Chloroacetone	Chloroacetaldehyde
Hydrogen bromide	Chloroacetonitrile	Chloroacetyl chloride
Hydrogen chloride	Chlorosulfonic acid	Crotonaldehyde
Hydrogen cyanide	Diketene	Cyanogen chloride
Hydrogen fluoride	1,2-Dimethylhydrazine	Dimethyl sulfate
Hydrogen sulfide	Ethylene dibromide	Diphenylmethane-4,4'-diisocyanate
Nitric acid, fuming	Hydrogen selenide	Ethyl chloroformate
Phosgene	Methanesulfonyl chloride	Ethyl chlorothioformate
Phosphorus trichloride	Methyl bromide	Ethyl phosphonothioic dichloride
Sulfur dioxide	Methyl chloroformate	Ethyl phosphonic dichloride
Sulfuric acid	Methyl chloroslane	Ethylenimine
Tungsten hexafluoride	Methyl hydrazine	Hexachlorocyclopentadiene
	Methyl isocyanate	Hydrogen iodide
	Methyl mercaptan	Iron pentacarbonyl
	Nitrogen dioxide	Isobutyl chloroformate
	Phosphine	Isopropyl chloroformate
	Phosphorus oxychloride	Isopropyl isocyanate
	Phosphorus pentafluoride	n-Butyl chloroformate
	Selenium hexafluoride	n-Butyl isocyanate
	Silicon tetrafluoride	Nitric oxide
	Stibine	n-Propyl chloroformate
	Sulfur trioxide	Parathion
	Sulfuryl chloride	Perchloromethyl mercaptan
	Sulfuryl fluoride	sec-Butyl chloroformate
	Tellurium hexafluoride	tert-Butyl isocyanate
	n-Octyl mercaptan	Tetraethyl lead
	Titanium tetrachloride	Tetraethyl pyrophosphate
	Trichloroacetyl chloride	Tetramethyl lead
	Trifluoroacetyl chloride	Toluene 2,4-diisocyanate
		Toluene 2,6-diisocyanate

Source: "Summary of the Final Report of the International Task Force 25: Hazard from Industrial Chemicals," April 15, 1999.

OSHA divides TIMs into three hazard categories.

High hazard	• Widely produced, stored, or transported TIM • High toxicity • Easily vaporized
Medium hazard	• May rank high in some categories but is lower in others such as number of producers, physical state, or toxicity
Low hazard	• Not likely to be a hazard unless specific operational factors indicate otherwise

8–132

Be familiar with SOPs/SOGs for handling chemical terrorist attacks and hazardous materials incidents.

The primary operational objective at a chemical attack is to do the greatest good for the greatest number

Chemical attacks may differ from other hazmat incidents

Severity of hazards present	Possibility of secondary devices	Mass casualties	Need for rapid decon	Administration of antidotes

8–133

REVIEW QUESTIONS

What are indicators of a chemical attack?

What types of chemical attack agents are first responders most likely to encounter? Why?

How might chemical attacks differ from other hazmat incidents?

8–134

Learning Objective 6

Identify indicators and types of biological attacks.

8–135

Terrorist attacks using biological agents are a possibility.

The Centers for Disease Control and Prevention (CDC) defines biological terrorism as

"An intentional release of viruses, bacteria, or their toxins for the purpose of harming or killing citizens"

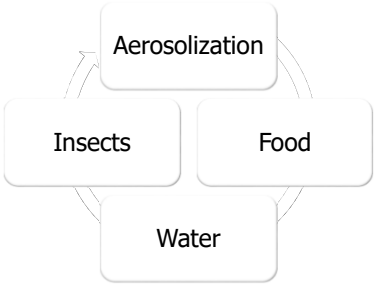
8–136

Be familiar with four types of biological agents.

Viral agents	• Simplest types of microorganisms • Can only replicate in their host's living cells • Do not respond to antibiotics
Bacterial agents	• Microscopic, single-celled organisms • Two different disease mechanisms possible: invading the tissues or producing poisons (toxins)
Rickettsia	• Specialized bacteria that live and multiply in arthropods' gastrointestinal tracts • Most spread only through the bite of infected arthropods, not via human contact
Biological toxins	• Poisons produced by living organisms • Similar to chemical agents in the way they are disseminated and in their effectiveness as biological weapons

8–137

Biological agents can be transmitted in multiple ways



8–138

An attack using a biological weapon may not be immediately obvious.

Generally, biological weapons 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

Source of the attack may be difficult to trace

8–139

Signs and symptoms of a biological attack may take many days to develop.

Biological attack indicators include

- Warning or threat of an attack or received intelligence
- Presentation of specific unusual diseases such as smallpox
- Unusual number of sick or dying people or animals
- Multiple casualties with similar signs or symptoms
- Dissemination of unscheduled or unusual spray
- Abandoned spray devices

(Cont.)

8–140

Signs and symptoms of a biological attack may take many days to develop.

Biological attack indicators include

- Nonendemic illness for the geographic area
- Casualty distribution aligned with wind direction
- Electronic tracking of signs and symptoms
- Illnesses associated with a common source or locations
- Many people with flu-like symptoms during non-flu months

8–141

Diseases can be transmitted in multiple ways.

8–142

Diseases can be transmitted in multiple ways.

Airborne transmission (inhalation of airborne organisms or toxins)	• Diseases remain suspended in air • When inhaled may penetrate deep into the respiratory tract • These diseases can typically survive outside the body for long periods of time
Contact with infected droplets	• Infected droplets transmit diseases through contact with mucous membranes • Droplets generally do not stay airborne for long periods of time
Direct contact (such as touching or kissing an infected person)	• Most sexually transmitted diseases transmitted this way • Other diseases transmitted in this way typically do not survive outside the human body for long

(Cont.)

8–143

Diseases can be transmitted in multiple ways.

Indirect contact (such as touching contaminated surfaces)	• Indirect contact diseases can generally survive on exposed surfaces for extended periods of time
Ingestion of contaminated food or water	• Normally this occurs due to contact with infected fecal material
Vectors	• Some diseases are spread by insects and animals

8–144

NOTE

Many diseases have more than one route of transmission.

8–145

Infectious and contagious are not the same thing.

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

An attack with a contagious agent has the potential to become an epidemic

Noncontagious diseases will only affect those individuals who have direct exposure to the disease agent itself

8–146

Operations at biological attack incidents or bioterrorism will most likely cross jurisdictional boundaries.

Planning efforts must include provisions for sharing

- Resources
- Information
- Management

8–147

Responders should use common infection control procedures to protect themselves from biological agents.

8–148

You must know when to follow Universal Precautions.

Universal precautions include	Use disposable gloves
	Change gloves between patients to prevent transmitting the infection from patient to patient
	Wash hands immediately after removing gloves
	Use disposable PPE and a face shield if you anticipate any splashing

8–149

In an overt attack or incident, focus on isolation and containment of the biological agent.

Measures that may contain indoor attacks include

- Turning off ventilation systems
- Closing doors and windows
- Turning off elevators
- Sealing ducts, windows, and doors using tape, plastic sheets, and expanding foams to restrict air flow

(Cont.)

8–150

In an overt attack or incident, focus on isolation and containment of the biological agent.

Measures that may contain outdoor attacks include

- Cover the device or dispersed agent with tarps or other physical barriers to prevent spreading
- Decontaminate the dispersed agent with a light spray of water and bleach
- Secure and place the suspicious item, package, object, or substance in a sealed hazmat recovery bin or container to mitigate spreading

8–151

Individuals who may have been exposed must be assessed.

If possible, keep individuals who have been exposed to biological agents from leaving the scene until a thorough risk assessment has been conducted and appropriate measures taken

Decontamination is recommended for any credible threat involving aerosols or contact with potentially harmful substances

8–152

Know containment guidelines.

Initially contain persons that may be affected

Decontaminate victims if circumstances indicate the need prior to treatment and transport to a medical facility

Register (record name and contact information) all persons potentially exposed at the incident in case follow-up is required

8–153

REVIEW QUESTIONS

What four types of biological agents are likely to be used in a biological attack?

What are indicators of a probable biological attacks and how do they differ from chemical or explosive attack indicators?

8–154

Learning Objective 7

Identify indicators and types of possible radiological attacks.

8–155

Response to a radiological incident is likely to be similar to the response to other emergency incidents.

Responders may not immediately detect the presence or involvement of radiological materials

Emergency response agencies must include radiation monitoring as a normal part of response to any fire and/or explosion incident

The only way to confirm if radiation is present at an incident is to use radiological monitoring equipment

8–156

A nuclear attack will probably overwhelm responders and require outside assistance.

Because nuclear attacks are extremely unlikely, the following sections will only address radiological devices

8–157

Radiological attacks utilize weapons that release radiological materials.

Radiological attack indicators include	Warning or threat of an attack or received intelligence
	Individuals exhibiting signs and symptoms of radiation exposure
	Radiological materials packaging left unattended or abandoned in public locations
	Suspicious packages that seem to weigh more than their appearance
	Activation of radiation detection devices, with or without an explosion
	Material that is hot or seems to emit heat without any sign of an external heat source
	Glowing material

8–158

Nuclear attacks are the intentional detonation of a nuclear weapon.

Indicators of nuclear attacks include

- Warning or threat of an attack or received intelligence
- Mushroom cloud
- Exceptionally large/powerful explosion
- Electromagnetic pulse (EMP)

8–159

Several types of designs exist for radiological devices.

Radiological devices are designed to expose people to radiation or disperse radiological material

Sometimes referred to as *dirty bombs*

These devices include radiation-emitting devices (REDs), radiological-dispersal devices (RDDs), and radiological-dispersal weapons (RDWs)

8–160

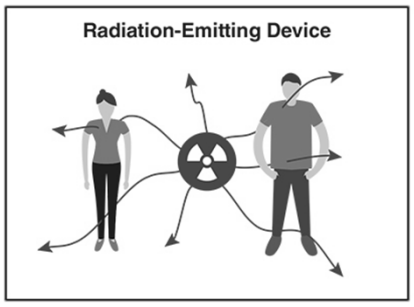
A radiation-emitting device (RED) is a powerful gamma-emitting radiation source.

Terrorists may

- Place it in a high-profile location to expose a large number of people to the intense radiation source
- Use REDs to target specific individuals and/or harm a limited number of people over a long period of time

8–161

Radiation-emitting devices emit gamma radiation.



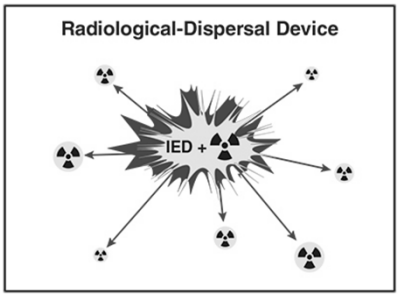
8–162

A radiological-dispersal device (RDD) is designed to disseminate radioactive material in order to cause harm.

- Intended to disperse radioactive material over a large area
- Used to create fear and panic
- Typically uses the force of conventional explosives to scatter radioactive material

8–163

Radiological-dispersal devices use explosives to scatter radioactive materials over an area.



8–164

Radiological-dispersal weapons (RDWs) are nonexplosive RDDs.

- Can use inexpensive and common items to spread radioactive contamination
- Examples include
  - Pressurized containers
  - Building ventilation systems
  - Fans
  - Mechanical devices

8–165

Radiological dispersal weapons use common items to disperse radioactive materials.

8–166

The ICS and local/jurisdictional procedures will establish priorities at radiological incidents.

- For most terrorism events, individual fire departments will eventually fold into a larger Incident Command Structure
- After multiple agencies with overlapping authority arrive, a Unified Command Structure will establish incident control
- Until those agencies arrive, the AHJ's Incident Management System will provide the necessary incident management structure

8–167

Regardless of the entity in Command, responders will need to gather essential information.

Responders conducting scene size-up need to look for

- Unusual or out-of-place incident-scene indicators
- Size and shape of smoke plumes
- Odors
- Large debris fields
- Craters from explosions

8–168

Geographic and environmental factors can complicate a radiological terrorism incident.

Prevailing winds that can carry airborne radioactive particulates	Broken water mains	Vehicle and/or pedestrian traffic flow
Ventilation systems	Air and rail corridors	Natural or man-made influences

8–169

Be familiar with possible radiological incident tactics.

- Position apparatus upwind of the incident
- Secure the area and prevent unauthorized entry
- Stay alert and look for small explosive devices designed to disseminate an agent
- Use time, distance and shielding as protective measures
- Use full PPE, including SCBA
- Avoid contact with any visible smoke or fumes
- Monitor radiation and contamination levels

(Cont.)

8–170

Be familiar with possible radiological incident tactics.

- Establish background radiation levels outside the suspected contamination area
- Detain or isolate uninjured people or equipment
- Remove victims from high hazard areas
- Assist the medical personnel as necessary to triage, treat, and decontaminate trauma victims
- Call for expert guidance, following AHJ SOPs
- Preserve possible evidence for subsequent criminal and forensic investigations
- Do not conduct overhaul and clean-up operations; avoid disturbing the incident scene as much as possible

8–171

REVIEW QUESTION

List types of radiological devices.

8–172

Learning Objective 8

Identify general hazards at illicit laboratories.

8–173

Illicit laboratories may be used to manufacture a variety of substances.

- Drugs
- Explosives
- Biological weapons
- Chemical warfare agents

8–174

This small, box meth lab is portable.

Courtesy of MSA

8–175

Illicit labs can be extremely hazardous.

Stop

Get out

Report it to authorities immediately!

8–176

Know the clues that may indicate an illicit laboratory.

- Laboratory glassware in unusual locations
- Large quantities of household chemicals and pharmaceuticals
- Hot plates
- Unusual odors in unexpected places such as hotel rooms
- Unusual uses of common materials such as coffee filters, water bottles, coffee grinders
- Increased security such as barred windows
- Unusual traffic patterns such as pedestrian and vehicular
- Unusual behavior and suspicious activity
- Personal protective equipment such as gloves, masks
- Disinfectants

8–177

Different types of labs have different key indicators.

Table 8.10
Illicit Lab Indicators

Methamphetamine Lab Indicators	Explosives Lab Indicators	Biological (Including Ricin) Lab Indicators	Chemical Weapons Lab Indicators
Packages of cold medicine	Blasting caps	Agent samples: soil, blood, or organs; vials from commercial vendors	Chemical agent detection kits
Unusual numbers of matches	Detonation cord	Agar plates, petri dishes, liquid growth medium	Auto injector antidotes for nerve agents
Propane tanks with blue fittings	Wires, fuses, batteries, switches	Castor beans or plants	Cyanide salts
Hot plates, camp stoves, deep fryer, mantles	Tubes, pipes, potential shrapnel components (nails, bolts, broken glass)	Fermenters	Chemicals including: • Phosgene • Thiodiglycol • Thionyl chloride • Phosphorous trichloride
Capped two-liter or quart containers with clear (most commonly) to opaque liquids used in "one-pot" method	Ammonium nitrate	Drying and milling equipment	Commercial chemical glassware and chemical containers
Red phosphorous	Hexamine fuel tablets	Sterilization equipment	Chemistry textbooks
Lithium	Fuel oil	Incubators	Pressurized spray bottles for dissemination
Hydriodic acid	Urea nitrate	Animals in cages (alive or dead)	Animals in cages (alive or dead)

8–178

REVIEW QUESTION

What are clues to an illicit laboratory?

8–179

Learning Objective 9

Recognize illegal hazmat dumps.

8–180

Illegal chemical dumps may occur in any jurisdiction.

- Lawful disposal may seem too expensive or complicated
- Materials in illicit labs or other illegal activities
- Dumpsites may have existed years before regulations prohibited such actions

8–181

Illegal dumps frequently pose significant problems and hazards.

Unlabeled containers	• Disposers may have removed chemicals from original containers or labels • Identification information may have been deliberately removed
Mixed chemicals	• Containers and dump sites may have many different (and potentially incompatible chemicals) mixed together, making hazard and risk assessment difficult
Aged chemicals	• Many chemicals become unstable when subjected to age and weathering in outside climates
Environmental contamination	• Becomes a serious issue when chemicals dumped into water • Leaking drums and other containers can pose a threat to groundwater sources

8–182

REVIEW QUESTION

What hazards are frequently encountered at illegal hazmat dumps?

8–183

Learning Objective 10

Describe hazmat operations after disasters.

8–184

Natural disasters can create hazmat incidents.

Courtesy of FEMA, photo by Liz Roll

Hazmat containers may be damaged and/or moved far from their original locations during natural disasters

8–185

Massive quantities of household waste can be generated after a disaster.

Courtesy of FEMA, photo by Greg Henshall

These propane containers were collected after a disaster in the U.S.

8–186

Hazmat containers may wash downstream during a flood.

Courtesy of Rich Mahaney

A bridge showing some of the drums and hazmat containers washed downstream during a flood

8–187

Problems created by natural disasters may overwhelm local response capabilities.

- Know who and how to call for assistance
- Keep in mind the need to follow all hazardous waste rules for disposal of orphaned hazardous materials
- Include consideration of potential disasters in your preincident surveys and preplanning

8–188

After a flood, contaminated sandbags pose a hazardous materials disposal issue.

Courtesy of Rich Mahaney

8–189

REVIEW QUESTION

What are some problems and hazards that disasters may create?

8–190

Chapter 8: Implementing the Response: Terrorist Attacks, Criminal Activities, and Disasters

Key Terms

1. **CBRNE** – Abbreviation for Chemical, Biological, Radiological, Nuclear, and Explosive. These categories are often used to describe WMDs and other hazardous materials characteristics.
2. **Agroterrorism** – Terrorist attack directed against agriculture, such as food supplies or livestock.
3. **Cyber Terrorism** – Premeditated, politically motivated attack against information, computer systems, computer programs, and data which result in violence against noncombatant targets by subnational groups or clandestine agents.
4. **Triacetone Triperoxide (TATP)** – Triacetone triperoxide (TATP) is typically a white crystalline powder with a distinctive acrid (bleach) smell and can range in color from a yellowish to white color. *Similar to* Hexamethylene triperoxide diamine (HMTD).
5. **High Explosive** – Explosive that decomposes extremely rapidly (almost instantaneously) and has a detonation velocity faster than the speed of sound.
6. **Detonation** – Explosion with an energy front that travels faster than the speed of sound.
7. **Ammonium Nitrate and Fuel Oil (ANFO)** – High explosive blasting agent made of common fertilizer mixed with diesel fuel or oil; requires a booster to initiate detonation.
8. **Low Explosive** – Explosive material that deflagrates, producing a reaction slower than the speed of sound.
9. **Deflagrate** – To explode (burn quickly) at a rate of speed slower than the speed of sound.
10. **Incendiary Device** – (1) Contrivance designed and used to start a fire. (2) Any mechanical, electrical, or chemical device used intentionally to initiate combustion and start a fire. *Also known as* Explosive Device.
11. **Primary Explosive** – High explosive that is easily initiated and highly sensitive to heat; often used as a detonator. *Also known as* Initiation Device.
12. **Detonator** – Device used to trigger less sensitive explosives, usually composed of a primary explosive; for example, a blasting cap. Detonators may be initiated mechanically, electrically, or chemically.
13. **Secondary Explosive** – High explosive that is designed to detonate only under specific circumstances, including activation from the detonation of a primary explosive. *Also known as* Main Charge Explosive.
14. **Tertiary Explosive** – High explosive that require initiation from a secondary explosive. Tertiary explosives are often categorized with secondary explosives. *Also known as* Blasting Agents.
15. **Munitions –** Military reserves of weapons, equipment, and ammunition.
16. **Homemade Explosive (HME)** – Explosive material constructed using common household chemicals. The finished product is usually highly unstable.
17. **Hexamethylene triperoxide diamine (HMTD)** – Peroxide-based white powder high explosive organic compound that can be manufactured using nonspecialized equipment. Sensitive to shock and friction during manufacture and handling. *Similar to* acetone peroxide (TATP).
18. **Person-Borne Improvised Explosives Device (PBIED)** – Improvised explosive device carried by a person. This type of IED is often employed by suicide bombers, but may be carried by individuals coerced into carrying the bomb.
19. **Explosive Ordnance Disposal (EOD)** – Emergency responders specially trained and equipped to handle and dispose of explosive devices. *Also called* Hazardous Devices Units *or* Bomb Squad.
20. **Vehicle-Borne Improvised Explosives Device (VBIED)** –An improvised explosive device placed in a car, truck, or other vehicle. This type of IED typically creates a large explosion.
21. **Mobile Data Terminal (MDT)** – Mobile computer that communicates with other computers on a radio system.
22. **Chemical Attack** – Deliberate release of a toxic gas, liquid, or solid that can poison people and the environment.
23. **Chemical Agent** – Chemical substance that is intended for use in warfare or terrorist activities to kill, seriously injure, or incapacitate people through its physiological effects. *Also known as* Chemical Warfare Agents.

24. **Nerve Agent** – A class of toxic chemical that works by disrupting the way nerves transfer messages to organs.
25. **Volatility** – Ability of a substance to vaporize easily at a relatively low temperature.
26. **Persistent Chemical Agent** – Chemical agent that remains effective in the open (at the point of dispersion) for a considerable period of time, usually more than 10 minutes.
27. **Nonpersistent Chemical Agent** – Chemical agent that generally vaporizes and disperses quickly, usually in less than 10 minutes.
28. **G-Series Agents –** Nonpersistent nerve agents initially synthesized by German scientists.
29. **Antidote** – Substance that counteracts the effects of a poison or toxin.
30. **Autoinjector** – Spring-loaded syringe filled with a single dose of a lifesaving drug.
31. **Blister Agent –** Chemical warfare agent that burns and blisters the skin or any other part of the body it contacts. *Also known as* Vesicant *and* Mustard Agent.
32. **Chemical Asphyxiant** – Substance that reacts to prevent the body from being able to use oxygen. *Also known as* Blood Agent.
33. **Choking Agent** – Chemical warfare agent that attacks the lungs, causing tissue damage.
34. **Riot Control Agent** – Chemical compound that temporarily makes people unable to function, by causing immediate irritation to the eyes, mouth, throat, lungs, and skin.
35. **Antibiotic** – Antimicrobial agent made from a mold or a bacterium that kills or slows the growth of bacteria; examples include penicillin and streptomycin. Antibiotics are ineffective against viruses.
36. **Biological Agent** – Viruses, bacteria, or their toxins which are harmful to people, animals, or crops. When used deliberately to cause harm, may be referred to as a Biological Weapon.
37. **Vector** – An animate intermediary in the indirect transmission of an agent that carries the agent from a reservoir to a susceptible host.
38. **Pandemic** – Epidemic occurring over a very wide area (several countries or continents), usually affecting a large proportion of the population.
39. **Radiation-Emitting Device (RED)** – Powerful gamma-emitting radiation source used as a weapon.
40. **Radiological Dispersal Weapons (RDW)** – Devices that spread radioactive contamination without using explosives; instead, radioactive contamination is spread using pressurized containers, building ventilation systems, fans, and mechanical devices.

True/False

1. True
2. False
3. False
4. True
5. False
6. True
7. False
8. True
9. True
10. False
11. False
12. True

Fill in the Blank

1. monitoring equipment.
2. radiation exposure
3. electromagnetic pulse
4. radioactive

5. high-profile
6. nuclear
7. powder, liquid
8. craters
9. environmental
10. entry
11. background, contamination
12. decontamination
13. overhaul

Picture Identification

Explosive Devices and Components Used in Terror Attacks
1. Suicide bomb or person-borne improvised explosive device (PBIED)
2. ANFO or Ammonium nitrate and fuel oil
3. IED or improvised explosive device
4. Pipe bomb
5. TATP or Triacetone triperoxide
6. Briefcase bomb
7. Black powder
8. TNT

Suicide Bomb Vest
Photo (WB 8.16)

Methods of Infectious Disease Transmission

1-A. Direct contact
1-B. Sexually transmitted diseases

2-A. Ingestion
2-B. Through contact with fecal matter

3-A. Vectors
3-B. Lyme disease and bubonic plague

4-A. Airborne
4-B. Yes

5-A. Infected droplets
5-B. Eyes, nose, and mouth

6-A. Indirect contact
6-B. Exposed surfaces

Matching

Targeted versus Nontargeted Incident

1. A
2. B
3. B
4. A

Chemical Attacks

1. E
2. F
3. B
4. G
5. A
6. B
7. F
8. A
9. C

Radiological Devices

1. C
2. A
3. B
4. C
5. A
6. B

Short Answer

1. *Answers may vary; students should include at least three of the following.*
   Drugs
   Explosives
   Biological weapons
   Chemical warfare agents
2. *Answers may vary; students should include at least four of the following.*
   Laboratory glassware in unusual locations
   Large quantities of household chemicals and pharmaceuticals
   Hot plates
   Unusual odors in unexpected places such as hotel rooms
   Unusual uses of common materials such as coffee filters, water bottles, coffee grinders
   Increased security such as barred windows
   Unusual traffic patterns such as pedestrian and vehicular
   Unusual behavior and suspicious activity
   Personal protective equipment such as gloves, masks
   Disinfectants
3. *Answers may vary; students should include some of the following.*
   Some illegal disposers may consider lawful disposal too expensive or complicated
   The disposers may have used the materials in illicit labs or other illegal activities;
   Some chemical dumpsites may have existed years before any regulations prohibited such actions

4. *Answers may vary; students should include some of the following.*
   Unlabeled containers
   Mixed chemicals
   Aged chemicals
   Environmental contamination
5. *Answers may vary; students should include some of the following.*
   Flood waters may move containers of all shapes, sizes, and contents;
   Floods can float tanks off foundations and sweep away entire chemical storage yards
   If storage tank leaks, chemicals can be released into the flood waters
6. *Answers may vary; students should include two of the following.*
   Know who and how to call for assistance;
   Follow all hazardous waste rules for disposal of orphaned hazardous materials;
   Seek federal help

Hazardous Materials for First Responders Fifth Edition

Chapter 9 — Implementing the Response: Personal Protective Equipment

HAZARDOUS MATERIALS FOR FIRST RESPONDERS
FIFTH EDITION

IFSTA

Learning Objective 1

Describe respiratory protection used at hazardous materials incidents.

9–1

Protective breathing equipment prevents the inhalation of hazardous substances when used correctly.

Respiratory protection is a primary concern for first responders

Inhalation is the most significant route of entry for hazardous materials

9–2

Responders use one of these basic types of protective breathing equipment at hazmat/WMD incidents.

- Self-contained breathing apparatus (SCBA)
  - Closed circuit SCBA
  - Open circuit SCBA
- Supplied air respirators (SARs)
- Air-purifying respirators (APRs)
  - Particulate-removing
  - Vapor-and-gas-removing
  - Combination particulate-and-vapor-and-gas-removing
- Powered air-purifying respirators (PAPRs)

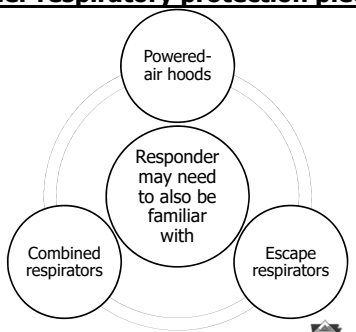
9–3

WARNING

You must wear your SCBA during emergency operations at terrorist/hazmat incidents until air monitoring and sampling determines other options are acceptable.

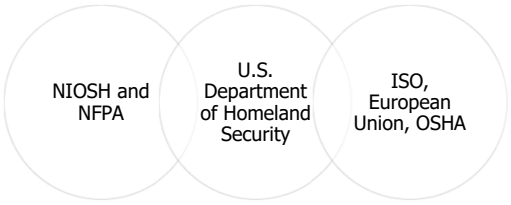
9–4

Each type of respiratory equipment has limits and may need to be paired with another respiratory protection piece.



9–5

Standards for respiratory protection at hazmat/WMD incidents have been developed and adopted.



9–6

The U.S. Department of Homeland Security has adopted standards for respiratory equipment.

To protect responders at hazmat/WMD incidents

NIOSH
- Certifies SCBA
- Recommends ways to select, use protective clothing and respirators at biological incidents

9–7

SCBA is a very important piece of PPE for a responder at a hazmat incident.

SCBA unit consists of
- Facepiece
- Pressure regulator
- Air hoses
- Compressed air cylinder
- Harness assembly
- End-of-service-time indicators (low-air supply or low-pressure alarms)

9–8

SCBA used in IDLH atmospheres must be certified.

Certified by NIOSH and MSHA	NFPA 1981	ANSI standards for eye protection
Do NOT use SCBA that are not certified	Lists design and testing criteria	Applies to facepiece lens design and testing

9–9

SCBAs are classified as either closed- or open-circuit.

Two manufactured types
- Pressure-demand
- Positive-pressure

SCBA may also be either
- High-pressure type
- Low-pressure type

9–10

Use only positive-pressure open- or closed-circuit SCBA when you are exposed to hazardous materials.

9–11

There are advantages and disadvantages of using open-circuit SCBA.

Advantages

- Independence
- Maneuverability
- Protection from toxic and/or asphyxiating atmospheres

Disadvantages

- Weight of unit
- Limited air supply
- Change in profile may hinder mobility
- Limited vision
- Limited communication

9–12

Certain SBCAs are approved by NIOSH for use during WMD incidents.

A NIOSH label showing compliance with CBRN criteria

CBRN SCBA labeled for easy identification

On SCBA backplate, on the upper corner or in the areas of the cylinder neck

9–13

SARs or airline respirators are atmosphere-supplying respirators.

Courtesy of MSA

Apparatus usually consists of

- Facepiece
- Belt- or facepiece-mounted regulator
- Voice communications system
- Up to 300 feet (90 m) of air supply hose
- Emergency escape pack or emergency breathing support system (EBSS)
- Breathing air source that user does not carry

9–14

SAR are not certified for fire fighting operations.

Potential airline damage from

- Heat
- Fire
- Debris

9–15

NIOSH classified SARs as Type C respirators.

Divided into two approved types

Regulator and facepiece only

Regulator, facepiece, and EBSS

SAR with escape (egress) capabilities	Used in confined-space and IDLH or potential IDLH environments

9–16

Responders at hazmat and CBR incidents can use any of the approved Type 2 respirators with one limitation.

SAR

SAR with escape (egress) capabilities

Must have positive pressure to facepiece

9–17

SARs have advantages and limitations.

Advantages

- Reduces physical stress to the wearer by removing weight of SCBA

Limitations

- Potential for damage to air-supply line
- Short air-line (no more than 300 feet [90 m] from the air source) restricts mobility
- Issues with hose entanglement
- Restricted vision and communications

Air-purifying respirators (APRs) or powered APRs (PAPRs) use specific purifying elements to filter air.

Three types of air-purifying elements

- Particulate-removing
- Vapor-and-gas-removing
- Combination particulate-removing and vapor-and-gas-removing

APRs have either full or half facepieces.

Full and half facepieces provide a complete seal to the face

- Full facepieces also provide eye protection

Half facepieces do NOT protect against CBR materials that can be absorbed through the skin or eyes

- Not recommended for use at hazmat/WMD incidents except in very specific situations

APRs should not be used where unknown atmospheric conditions exist.

Courtesy of U.S. Marine Corp, photo by Cpl. Alissa Schuning

APRs do not provide oxygen from a separate source and only protect against specific contaminants at or below certain concentrations

APR facepiece has disposable filters, canisters, or cartridges that remove specific contaminants from the air.

Filters, canisters, or cartridges located on one or both sides of facepiece

Air enters APR through facepiece either from external atmosphere or through user exhalation

Air passed through facepiece into filter, sorbent, catalyst, or a combination of the three; specific contaminants are removed

No single APR canister, filter, or cartridge can protect user against all chemical hazards.

Ask these questions to determine what APR canister, filter, or cartridge to use

- 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?

WARNING

Do not wear APRs during emergency operations where unknown atmospheric conditions exist. Wear APRs only in controlled atmospheres where the hazards present are completely understood and at least 19.5 percent oxygen is present.

9–24

APRs offer limited protection.

- No protection against oxygen-deficient, oxygen-enriched, or IDLH atmospheres
- Limited life of its filters and canisters
- Need for constant monitoring of contaminated atmosphere

9–25

Use precautions when using APRs.

- Know what and how much of the chemicals/air contaminants are in the air
- Ensure that the oxygen level is between 19.5 and 23.5 percent
- Ensure that atmospheric hazards are below IDLH conditions.

9–26

APRs may be used in several types of hazardous incidents or situations.

Hazmat/WMD incidents	• After scene hazards have been properly identified
In other situations	• Law enforcement • EMS/medical personnel • Escape situations
CBRN situations	• Utilize a combination organic vapor/high efficiency particulate air (OV/HEPA) cartridge

9–27

Particulate-removing APRs protect user from particulates, including biological hazards, in the air.

Protect user from particulates in air

- Biological hazards, toxic dusts, metal fumes, asbestos
- HEPA filters (99.97%) used for medical emergencies

Used with half or full facepieces

- Eye protection required with half facepiece
- Includes disposable particle masks (dust masks) which offer limited protection

9–28

Particulate-removing APRs can protect users from airborne particulates at hazmat/WMD incidents.

Used with half or full facepieces

Eye protection required with half facepiece

9–29

Particulate-removing APRs are divided into three levels of filtration and three levels of filter degradation.

Three levels of filtration	Three categories of filter degradation
• 95% • 99% • 99.97%	• N — **N**ot resistant to oil • R — **R**esistant to oil • P — **P**resent when oil or nonoil lubricants are used

9–30

There may be high levels of contaminants in the air at hazmat/WMD incidents.

Courtesy of FEMA News Photos, photo by Andrea Booher.

Particulate-removing filters may be used to protect against toxic dusts, mists, metal fumes, asbestos, and some biological hazards

9-31

High-efficiency particulate air (HEPA) filters are used for medical emergencies

Must be 99.97 percent efficient

95 and 99 percent effective filters may be used depending on health risk hazard

9–32

Particle masks, or dust masks, are classified as particulate-removing air-purifying filters.

These disposable masks protect the respiratory system from large-sized particulates

- Provide very limited protection and should not be used to protect against chemicals or small particles

9–33

Vapor- and gas-removing APRs use a sorbent material to filter vapor and gases from the air.

Individual canisters protect against related groups of chemicals

Most manufacturers color-code vapor-and-gas removing filter/canisters for easy identification

Courtesy of MSA.

9–34

Powered air-purifying respirators (PAPRs) supply air under positive pressure.

PAPRs remove contaminants and supply purified air to full facepiece through a blower

Positive pressure system offers greater safety than standard APRs in case of leaks or poor facial seals

Air flow makes PAPRs more comfortable to wear

9–35

PAPRs can be used at decontamination operations and long-term operations during hazmat/WMD incidents.

9–36

WARNING

Do not use PAPRs in explosive or potentially explosive atmospheres.

9–37

Know how to safely use PAPRs.

- Should only be used in situations where atmospheric hazards are understood and at least 19.5 percent oxygen is present
- NOT safe to wear in atmospheres with unidentified potential respiratory hazards
- Should NOT be used during initial emergency operations before atmospheric hazards confirmed
- Continuous atmospheric monitoring is needed to ensure responder safety

9–38

Combination respirators include SAR/SCBA, PAPR/SCBA, and SAR/APR.

Courtesy of MSA

- Combination respirators can provide flexibility and extend work duration times in hazardous areas

9–39

Powered- and supplied-air hoods are simple to use and require no fit testing.

Courtesy of the U.S. Air Force, photo by Airman 1st Class Bradley A. Lail

- Loose fitting, lightweight respiratory protection
- Can be worn with glasses, facial hair, and beards

9–40

Respiratory equipment has limitations.

- Limited visibility
- Decreased ability to communicate
- Increased weight
- Decreased mobility
- Inadequate oxygen levels
- Chemical specific
- Psychological stress

9–41

CAUTION

Personnel wearing respiratory equipment must have good physical conditioning, mental soundness, and emotional stability due to the physiological and psychological stresses of wearing PPE.

9–42

REVIEW QUESTION

What are the different types of respiratory protection used at hazmat/WMD incidents, and for which types of incidents should each type be used?

9–43

Learning Objective 2

Explain varieties of protective clothing worn at hazardous materials incidents.

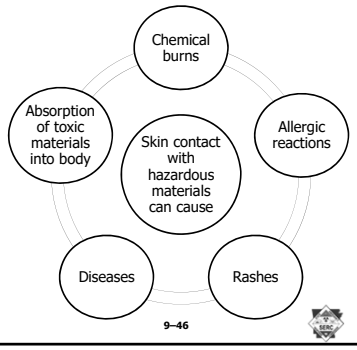
9–44

Protective clothing must be worn whenever a responder faces potential hazards.

- Thermal
- Exposure
  - Chemical
  - Biological
  - Radiological
- Ballistic

9–45

Protective clothing is designed to prevent potential bodily contact with hazardous materials.



9–46

Body armor and bomb suits can be worn to protect against ballistic and explosive hazards.

Courtesy of the U.S. Marine Corps, photo by Cpl. Antonio Rosas.

9–47

No single combination or ensemble of protective equipment can protect against all hazards.

Fire fighting turnout coats and pants	Chemical-protective clothing (CPC)
• Fumes and chemical vapors can penetrate	• Offers no protection from fires

9–48

When used correctly, appropriate PPE provides total user protection.

Skin	Eyes	Face
Hearing	Hands	Feet
Body	Head	Respiratory system

9–49

No one piece of PPE will protect against every hazard, no matter how versatile.

Technological advances are being made to improve versatility of all types of PPE

- However, understanding PPE's limitations is crucial to stay safe

9–50

CAUTION

When you respond to hazmat/WMD incidents, you must have the appropriate personal protective equipment (PPE) to perform your mission safely and effectively.

9–51

Correct use of PPE requires special training and instruction.

In accordance with standard operating procedures and manufacturer's recommendations	Under guidance of hazardous materials technician	Under supervision of allied professional

9–52

Responders should be familiar with PPE standards, design, certification, and testing .

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.

9–53

U.S. DHS adopted standards for CPC used at hazmat/WMD incidents, not for incendiary incidents.

9–54

Structural fire fighting protective clothing will provide limited protection against some hazardous materials.

9–55

Structural fire fighting clothing is NOT a substitute for CPC.

Protects user from some chemicals found in atmosphere of burning buildings

- SCBA protects against toxic gases
- Multiple layers of coat and pants may provide short-term protection from liquid chemicals

9–56

Structural fire fighting clothing is not an effective chemical barrier.

Protection limitations of multiple layers of coat and pants

- Neither corrosive-resistant nor vapor-tight
- Liquids can soak through
- Acids and bases can dissolve or deteriorate outer layers
- Gases and vapors can penetrate garment

9–57

Gaps in structural fire fighting clothing allow for penetration of chemicals.

Gaps occur at neck, wrists, waist, and at points where pants and boots overlap

9–58

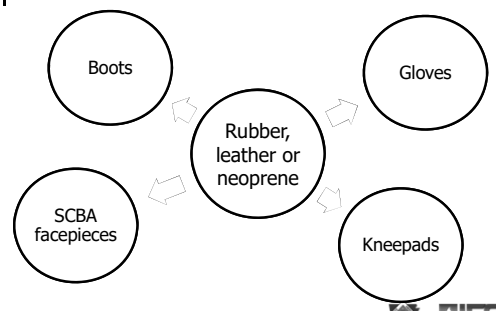
Some hazardous materials can permeate and remain in structural fire fighting clothing.

Chemicals absorbed into equipment can

- Cause repeated exposure
- Cause a later reaction with another chemical

9–59

Structural fire fighting PPE is made of materials susceptible to permeation and, if exposed, may need to be discarded.



9–60

Structural fire fighting protective clothing has limited use at hazmat incidents.

Some jurisdictions allow use of structural fire fighting protective clothing and SCBA to perform short-term duration operations

9–61

Structural fire fighting clothing with SCBA has advantages and limitations.

Advantages	• Protection against thermal damage during an explosive attack • May protect user from biological agents that are strictly respiratory
Limitations	• Limited or no protection against projectiles, shrapnel, and other mechanical effects from an explosive blast • Limited protection against radiological materials • Inadequate protection against skin contact with hazardous material

9–62

High-temperature protective clothing is used for short-term high temperature situations.

- Can withstand heat levels structural fire fighting clothing cannot
- Limited use against chemicals

9–63

Proximity and fire-entry suits are not interchangeable.

Proximity suits	• Permit close approach to fires
Fire-entry suits	• Allows user to walk into a total flame environment for short periods of time • Provides protection at radiant heat temperature as high as 2,000°F (1 100°C)

9–64

Proximity suits are frequently used in aircraft rescue and fire fighting.

Courtesy of the U.S. Marine Corps, photo by Cpl. William Hester.

9–65

WARNING

High temperature-protective clothing is not designed to protect the wearer against chemical hazards.

9–66

High temperature-protective clothing has limitations.

- Contributes to heat stress
- Bulky
- Limits wearer's vision and mobility
- Limits communication
- Requires frequent and extensive training
- Expensive to purchase
- Integrity of suit is designed for limited exposure time

9–67

Flame-resistant clothing is often everyday work wear for first responders.

9–68

Flame-resistant clothing will not ignite or melt when exposed to fire or radiant heat.

Designed for minimal exposure to

- Hot or molten materials
- Hot surfaces
- Radiant heat
- Flash fires
- Flame
- Electrical arc discharge

9–69

Flame-resistant clothing is made of flame-resistant fiber or by treating material with chemicals.

- Inherently flame-resistant (IFR)
  - Flame resistant without chemical additives
  - Protective properties cannot be washed out
- Flame retardant
  - Flame retardant chemical compound is added to fabric
  - Protective properties can be washed out

9–70

Chemical-protective clothing (CPC) is designed to protect against specific chemical hazards.

- CPC is made of a variety of materials
- Each material protects user from specific chemicals or products

9–71

WARNING

CPC is not is intended for fire fighting activities, nor for protection from hot liquids, steam, molten metals, welding, electrical arc, flammable atmospheres, explosive environments or thermal radiation.

9–72

CPC material can contribute to heat disorders.

- Designed to be impermeable to moisture
- Limits transfer of heat from body through natural evaporation

9–73

Users have considerations to make and duties to complete before and after wearing CPC.

Before using CPC

- Match each garment's degradation, permeation, and penetration abilities and service life based on the task at hand

After using CPC

- All CPC must be decontaminated after being used at an incident

9–74

WARNING

No single type of CPC protects against all chemical hazards.

You must have sufficient training to operate in conditions requiring the use of chemical-protective clothing.

9–75

Liquid-splash protective clothing, a type of CPC, is not designed to be completely gas- and vapor-tight.

9–76

There are two types of liquid-splash protection clothing.

Encapsulating

- One-piece suit with boots and gloves that are sometimes attached to the suit
- Protects users from splashes or vapors and gases
- Includes the Totally-Encapsulating Chemical Protective suit (TECP)

Nonencapsulating

- One-piece overall, but can also be composed of individual pieces
- Gaps between pants cuff and boots and between cuff and gloves are taped

9–77

An encapsulating suit covers the entire body and SCBA.

9–78

Nonencapsulating suits have their own limitations.

Nonencapsulating suit limitations

- Protects against splashes and dusts but not against gases and vapors
- Does not provide full body coverage: parts of head and neck are often exposed

9–79

Some of the limitations of encapsulating and nonencapsulating suits are similar.

Limitations of both types of suits

- Impairs user's mobility, vision, and communication
- Not resistant to heat or flames
- No protection against projectiles or shrapnel
- Traps body heat and causes heat stress

9–80

Both types of liquid splash-protection suits can be part of a PPE ensemble.

Encapsulating or nonencapsulating liquid splash-protection clothing

- SCBA
- SAR
- APR
  - Full-face

9–81

Vapor-protective clothing offers better protection from toxic vapors and gases than liquid splash-protective clothing.

9–82

NFPA 1991 sets performance requirements for vapor-tight, totally encapsulating chemical-protective suits.

Minimum protection level for responders facing specific chemical exposure

- Chemical-resistance
- Flame resistance
- Twenty-one chemical permeation test

9–83

Vapor-protective suits are often part of ensembles used in hazmat/WMD and other chemical and biological incidents.

Vapor-protective suits must be worn with either

- Positive-pressure SCBA
- Combination SCBA/SAR

9–84

Vapor-tight, totally encapsulating chemical-protective (TECP) suits are part of a EPA Level A protection ensemble.

9–85

Know the limitations of vapor-protective clothing.

- Melt and burn when exposed to fire
- Cannot be used in potentially flammable atmospheres
- Do not protect user against all chemical hazards
- Impairs mobility, vision, communication
- Do not allow body heat to escape and can contribute to heat stress
- May require the use of a cooling vest

9–86

CPC must be worn in certain types of operations by all responders.

- Site survey
- Rescue
- Spill mitigation
- Emergency monitoring
- Decontamination
- Evacuation

Consider known and unknown operational hazards and AHJ SOP/Gs when selecting protective clothing

9–87

Emergency response organizations have must a CPC and Respiratory Protection Management program.

A comprehensive CPC management program includes

- Hazard identification
- Medical monitoring
- Environmental surveillance
- Selection, care, testing, and maintenance
- Training

9–88

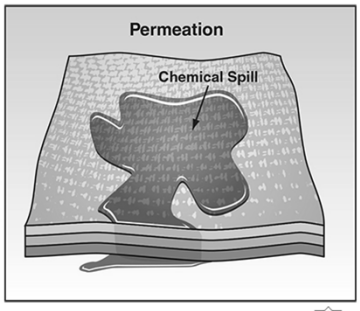
There are additional considerations when choosing PPE besides the known hazards at an incident.

CPC's effectiveness can be reduced by three actions

- Permeation
- Degradation
- Penetration

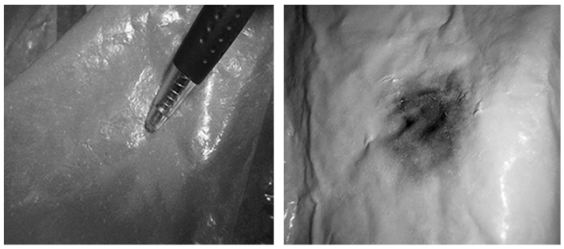
9–89

Permeation occurs when a chemical passes through fabric or material on a molecular level.



9–90

In most cases, there is no visible evidence of chemicals permeating material.



Courtesy of Barry Lindley.

9–91

Permeation data is provided by most CPC manufacturers.

Breakthrough time	• Time it takes chemical to permeate CPC material
Permeation rate	• Speed at which chemical moves though CPC material after it has permeated

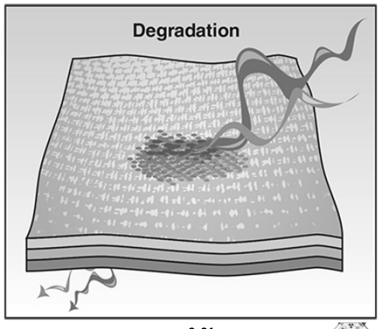
9–92

WARNING

Decontamination will not stop permeation from occurring.

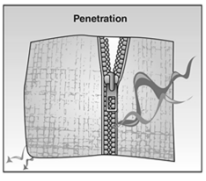
9–93

Chemical degradation occurs when the characteristics of a material are altered by contact with chemicals.



9–94

Penetration occurs when a hazardous material enters an opening or a puncture in protective material.



9–95

The service life of CPC affects user protection level.

Each piece of CPC has a specific service life, or expiration date

If CPC is contaminated, its service life is over and cannot be used again

9–96

WARNING

Never use CPC that is beyond its expiration date and/or has exceeded its service life.

9–97

REVIEW QUESTION

What are the major categories of protective clothing worn at hazardous materials incidents?

9–98

Learning Objective 3

Describe personal protective equipment ensembles used during hazardous materials incidents.

9–99

An adequate PPE ensemble requires respiratory protection, clothing, and consideration of the operation.

Hazards present

Actions needed to be preformed

PPE ensemble

9–100

WARNING

No single type of PPE protects against all hazards.

9–101

Regulatory agencies have established sets of PPE ensembles that provide specific levels of protection

EPA Chemical-protective PPE ensembles	Other organizations' PPE ensembles
• Used by fire and emergency service organizations	• PPE ensembles appropriate to hazards of their mission and SOPs

9–102

Types of PPE vary considerably.

Fire and emergency service organizations commonly use EPA established criteria for chemical protective PPE

Other organizations may have their own procedures guiding choice and use of appropriate combinations of PPE

Law enforcement	Industrial responders	Military

9–103

CAUTION

Always follow your agency's SOP/Gs in determining the level of PPE necessary to perform a task.

9–104

The four levels of EPA protective ensembles are used at hazmat/WMD incidents.

Level A | Level B | Level C | Level D

9–105

Levels are the starting point to creating protective ensembles.

Just having the right ensemble components is not enough

PPE ensembles need to be tailored for each specific incident based on known hazards

9–106

Level A ensembles provide the highest level of chemical protection.

Protects against hazardous

Vapors | Gases | Mist | Particles

9–107

The components of a Level A ensemble provide user protection and communication abilities.

- Positive-pressure, full facepiece, SCBA, or positive-pressure airline respirator with escape SCBA approved by NIOSH
- Vapor-protective suit: Totally-Encapsulated Chemical Protective (TECP) suit
- Optional coveralls, long underwear, hard hat
- Chemical-resistant inner and outer gloves
- Chemical-resistant boots with steel toe and shank
- Disposable protective suit, gloves, and boots (can be worn over totally encapsulating suit, depending on suit construction)
- Two-way radios (worn inside encapsulating suit)

9–108

Level B ensembles protect users against splashes from hazardous chemicals.

Level B CPC ensemble may be encapsulating or nonencapsulating

9–109

Level B ensembles have a lower level of skin protection, but the same level of respiratory protection as Level A.

Level B protection	Positive-pressure, full facepiece, SCBA, or positive-pressure airline respirator with escape SCBA approved by NIOSH
	Hooded chemical-resistant clothing (overalls and long-sleeved jacket, coveralls, one- or two-piece chemical splash suit, and disposable chemical-resistant overalls)
	Chemical-resistant inner and outer gloves
	Optional coveralls, face shield, disposable chemical-resistant outer boot covers
	Chemical-resistant boots with steel toe and shank
	Hard hat (outside or on top of nonencapsulating suits or under encapsulating suits)
	Two-way radios (worn inside encapsulating suit or outside nonencapsulating suit)

9–110

Know when it is appropriate to use Level B ensembles.

- Hazards have been identified but require less skin protection and high level of respiratory protection
- Atmosphere contains less than 19.5% oxygen or more than 23.5% oxygen
- Direct-reading organic vapor detection instrument detects an incompletely identified vapor but not chemicals harmful to or capable of being absorbed through intact skin
- Presence of liquids or particulates indicated, but they are not known to be harmful to or capable of being absorbed through intact skin

9–111

Level C protects users from hazardous chemical splashes.

Level C respiratory equipment includes all the various levels of APRs and PARPs

9–112

Level C protection is only used under specific conditions.

Specific material is known

Specific material has been measured

Protection level approved by IC after all qualifying conditions for APRs and PAPRs have been met

Product is known	Appropriate filter available	Atmospheric oxygen concentration is between 19.5 to 23.5 percent	Atmosphere is not IDLH

9–113

Level C ensembles have a lower level of respiratory protection but the same level of skin protection as Level B.

Level C Protection	Full-face or half-mask APRs, NIOSH approved
	Hooded chemical-resistant clothing (overalls, two-piece chemical-splash suit, and disposable chemical-resistant overalls)
	Chemical-resistant inner and outer gloves
	Chemical-resistant boots with steel toe and shank
	Hard hat
	Two-way radios (worn under outside protective clothing)
	Optional coveralls, escape mask, face shield, disposable chemical resistant boot covers

9–114

Level C protection ensembles can be used in environments safe for APR use.

- Atmospheric contaminants, liquid splashes, or other direct contact will not adversely affect or be absorbed through exposed skin
- Types of air contaminants have been identified, concentrations have been measured
- APR is available that can remove the contaminants
- Atmospheric concentration of chemicals does not exceed IDLH levels
- Atmosphere must contain between 19.5 and 23.5 percent oxygen

9–115

Level D ensembles consist of typical work uniforms, street clothing, or coveralls.

- Coveralls
- Chemical-resistant boots/shoes with steel toe and shank
- Safety glasses or chemical splash goggles
- Hard hat
- Optional gloves, disposable chemical-resistant outer boot covers, escape device in case of accidental release and need to immediately escape area, face shield

9–116

Level D ensembles are typically not worn in hot zones or hazmat responses above the Awareness level.

- Atmosphere contains no hazards
- Work functions preclude splashes, immersion, or potential for unexpected inhalation of or contact with hazardous levels of any chemicals

9–117

PPE selection is dependent on incident hazards and professional guidance.

Responder sources for PPE selection:

- Allied professionals
- Hazmat technicians
- Emergency response plan
- SOP/Gs
- IAP/Site Safety Plan

9–118

But, all responders should understand how to select appropriate PPE.

Generally, the higher the level of PPE, the greater the hazard

Overprotection, as well as underprotection, can be hazardous and should be avoided

9–119

Selecting operational PPE is a shared responsibility.

Ultimately chosen by IC

But responders should understand the selection process

PPE choice is dependent on both chemical and physical hazards.

Table 9.1
Effectiveness of Typical Fire Service PPE Ensembles for Specific Hazards

Fire Service Ensembles	Flammables/ Incendiaries*	Toxics/ Chemical Warfare Agents	Corrosives	Biological Hazards	Radiological Hazards	Explosives/ Ballistics
Standard Structural-Fire Fighting Ensemble Including SCBA**	Adequate	Inadequate for extended hot zone use***	Inadequate for extended hot zone use**	Varies Inadequate for incidents in which biological agents/ hazards or dissemination methods are unidentified or may still be occurring May be adequate in circumstances where agent/ hazard and dissemination methods are known	Adequate for Alpha and Beta radiation Inadequate for Gamma radiation	Inadequate for protection against explosives and ballistics Adequate for operations after an explosion not involving other CBRNE hazards

(Cont.)

Responders can consult resources to aid in PPE selection.

Chemical Protective Ensembles	Inadequate	EPA Level A, B, or C (NFPA 1994 Class 1, 2 and 3) as appropriate	EPA Level A, B, or C (NFPA 1994 Class 1, 2 and 3) as appropriate	EPA Level A, B, or C (NFPA 1994 Class 1, 2 and 3) as appropriate	Adequate for Alpha and Beta radiation Inadequate for Gamma radiation	Inadequate for protection against explosives or ballistics Adequate for operations after an explosion involving other CBR hazards as applicable
USAR Ensembles (without turnout gear)	Inadequate	Inadequate	Inadequate	Inadequate	Adequate for Alpha radiation with appropriate respiratory protection Inadequate for Beta and Gamma radiation	Inadequate for protection against explosives or ballistics Adequate for rescue and mitigation operations after an explosion not involving other CBR hazards

* Flammability should be given first priority when selecting PPE

**Not including turnout gear designed with improved CBR protection

***May be adequate for short duration exposures in certain situations (for example, during rescue operations, as determined by the Incident Commander, SOPs, or emergency response plan, etc.), and depending on the incident specifics.

NOTE

Many types of PPE do not provide thermal protection.

While choosing protective clothing, responders should consider multiple factors.

- Chemical and physical hazards
- Physical environment
- Exposure duration
- Available protective clothing or equipment
- Monitoring and detection readings
- Compliance with regulations

PPE ensemble components must be appropriate for whatever varied environmental conditions are present.

- Industrial settings, highways, or residential areas
- Indoors or outdoors
- Extremely hot or cold environments
- Uncluttered or rugged sites
- Required activities involving entering confined spaces, lifting heavy items, climbing ladders, or crawling on the ground

Exposure effects PPE choice.

- Exposure levels
- Material chemical-resistance
- Air supply
- Assume worst-case exposure so that appropriate safety margins can be added to ensemble wear times

9–126

Protective clothing selection factors include multiple factors.

- Clothing design
- Material chemical-resistance
- Physical properties
- Ease of decontamination
- Ease of maintenance and service
- Interoperability with other types of equipment
- Cost

9–127

Users may need to ask questions of manufacturers.

- Does material have sufficient strength to withstand physical demands of tasks at hand?
- Will material resist tears, punctures, cuts, and abrasions?
- Will material withstand repeated use after contamination and decontamination?
- Is material flexible or pliable enough to allow users to perform needed tasks?
- Will material maintain protective integrity and flexibility under hot and cold extremes?
- Is material subject to creation of a static electrical charge and discharge that could provide an ignition source?
- Is material flame-resistant or self-extinguishing (if these hazards are present)?
- Are garment seams in clothing constructed to provide same physical integrity as the garment material?

9–128

Protective ensembles will vary according to the responder's mission.

Responders of any discipline must be aware of

- Hazards present at incident
- What specific PPE is necessary to protect against hazards
- Personnel must be trained to use specific PPE

9–129

Fire service personnel will wear ensembles appropriate for their mission at the incident.

- Fire fighting operations
- Hazardous materials response
- Urban search and rescue

9–130

Fire service PPE provides differing levels of protection during a hazmat incident.

Table 9.2
Effectiveness of Typical Fire Service PPE Ensembles in the Hot Zone of CBRNE Incidents

Fire Service Ensembles	Incendiaries /Fires	Chemical Warfare Agents	TIMs	Biological Agents	Radiological Hazards	Explosives /Ballistics
Standard Structural-Fire Fighting Ensemble Including SCBA*	Adequate	Inadequate for extended hot zone use**	Inadequate for extended hot zone use**	Varies Inadequate for incidents in which agents or dissemination methods are unidentified or may still be occuring May be adequate in circumstances where agent and dissemination methods are known	Adequate for Alpha and Beta radiation Inadequate for Gamma radiation	Inadequate for protection against explosives and ballistics Adequate for operations after an explosion not involving other CBR hazards

(Cont.)

9–131

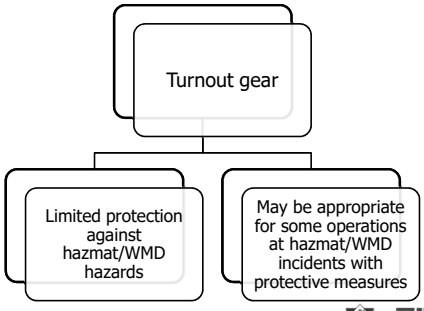
Fire service PPE provides differing levels of protection during a hazmat incident.

Haz-Mat/ Chemical Protective Ensembles	Inadequate	EPA Level A and B (NFPA® 1994 Class 1, 2 and 3) as appropriate	EPA Level A, B, or C Class 1, 2 and 3 as appropriate	EPA Level A, B, or C (NFPA® 1994 Class 1, 2 and 3) as appropriate	Adequate for Alpha and Beta radiation Inadequate for Gamma radiation	Inadequate for protection against explosives and ballistics Adequate for operations after an explosion involving other CBR hazards as applicable
US&R Ensembles (without turnout gear)	Inadequate	Inadequate	Inadequate	Inadequate	Adequate for Alpha radiation with appropriate respiratory protection Inadequate for Beta and Gamma radiation	Inadequate for protection against explosives and ballistics Adequate for rescue and mitigation operations after an explosion not involving other CBR hazards

*Not including turnout gear designed with improved CBR protection

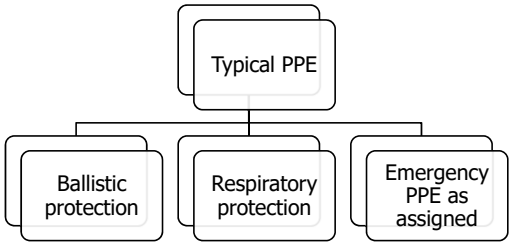
**May be adequate for short duration exposures in certain situations (for example, during rescue operations, as determined by the Incident Commander, SOPs, or emergency response plan, etc.), and depending on the agent.

Initially, most firefighters will be wearing structural fire fighting protective clothing ensembles (turn-out gear).



CPC trained fire responders can wear Level A or B ensembles at hazmat/WMD incidents.

Law enforcement personnel must be trained to use assigned PPE.



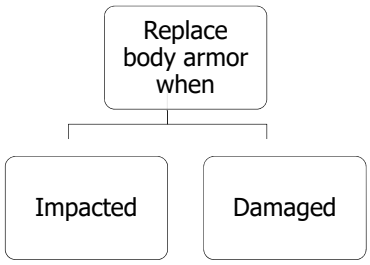
Various forms of law enforcement PPE have varying degrees of effectiveness in hazmat emergency incidents.

Table 9.3
Effectiveness of Typical Law Enforcement PPE in the Hot Zone of CBRNE Incidents

Law Enforcement PPE	Incendiaries/ Fires	Chemical Warfare Agents	TIMs	Biological Agents	Radiological Agents	Explosives/ Ballistics
Body Armor (w/ duty uniform)	Inadequate	Inadequate	Inadequate	Inadequate	Inadequate	Protection provided per type of armor
Haz Mat / Chemical Protective Ensembles	Inadequate	EPA Level A and B (NFPA® 1994 Class 1, 2 and 3) as appropriate	EPA Level A, B, or C (NFPA® 1994 Class 1, 2 and 3) as appropriate	EPA Level A, B, or C (NFPA® 1994 Class 1, 2 and 3) as appropriate	Adequate for Alpha and Beta radiation Inadequate for Gamma radiation	Inadequate for protection against explosives or ballistics Adequate for operations after an explosion involving other CBR hazards as applicable
Bomb Suits*	Adequate for flash fires	Inadequate	Inadequate	Varies Inadequate for incidents in which agents or dissemination methods are unidentified or may still be occurring	Adequate for Alpha and Beta radiation with appropriate respiratory protection Inadequate for Gamma radiation	Inadequate

*Not including bomb suits designed with improved CBR protection

Ballistic protection provided by body armor is used when attacks against first responders are likely.



Bomb disposal suits used by law enforcement provide full body protection.

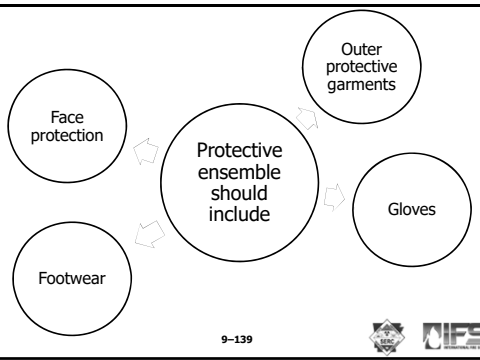
Courtesy of the U.S. Marine Corps, photo by Cpl. Brain A. Tuthill.

Protects against

- Fragmentation
- Overpressure
- Impact
- Heat
- Some CBR materials

9–138

EMS PPE must provide blood- and body-fluid pathogen barrier protection.



9–139

EMS protective ensembles protection levels vary according to hazmat zones.

Courtesy of MSA

EMS ensembles of high-quality respirators, butyl rubber gloves, and commercial chemical overgarments for personnel not working in hot zone

Particular PPE level may or may not be adequate for personnel conducting triage and decontamination operations in warm zone

9–140

REVIEW QUESTION

What are the Levels of Protection for PPE Ensembles?

What are factors that must be considered when selecting PPE ensembles?

How do typical PPE ensembles vary between fire service, law enforcement, and EMS personnel?

9–141

Learning Objective 4

Explain PPE related stresses.

9–142

Wearing PPE can cause extreme stress on the user.

Increased risk for heat and cold related disorders for PPE/CPC wearer

- Most PPE prevents body from releasing heat and moisture
- CPC Does not provide insulation

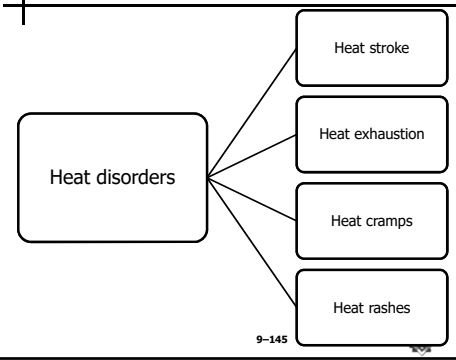
9–143

NOTE

Medical monitoring is required when environmental factors put you at risk.

9–144

Heat emergencies while wearing PPE can be fatal.



9–145

Heat-exposure while wearing PPE can be prevented or reduced.

Fluid consumption before and during operations involving PPE
Air cooling by fans or by wearing undergarments that provide natural ventilation
Ice cooling
Water cooling by misters or mobile showers
Cooling vests worn underneath PPE, but may be bulky and impair movement
Rest/rehab areas in shady areas or areas with misters or air conditioning
Work rotation with other responders
Proper liquids – Before working avoid alcohol and caffeinated drinks
Physical fitness of PPE user

9–146

Some agencies may use cooling vests to combat heat illness when using CPC.

9–147

Using a cooling vest can help avoid heat emergencies while using PPE.

Table 9.4
Examples of Cooling Vest Technologies

Passive Technologies	Method of Cooling
Ice	Ice packs in vest provides cooling
Evaporation	Wetted vest material provides evaporative cooling
Gel	Cold gel in vest provides cooling
Phase Change	Phase change material in vest slowly solidifies to maintain a consistent, cool temperature
Active Technologies*	**Method of Cooling**
Circulating Fluids	Chilled liquid is circulated through small tubes in vest
Forced Air	Air is circulated through tubes and blown into an air-space above the body

* Requires power to operate

9–148

Rehab can help prevent heat stress by allowing responders to cool off and rest.

Courtesy of Ron Jeffers.

9–149

NOTE

NFPA 1584, *Standard on the Rehabilitation Process for Members During Emergency Operations and Training Exercises*, addresses many of these issues.

PPE also heightens the risk for cold emergencies.

Caused by exposure to cold weather or to cryogenic liquids

Can result in serious health conditions

- Trench foot
- Frostbite
- Hypothermia

Knowing the causes of PPE cold-related emergencies can prevent responder injury or even death.

- Low temperatures
- High/cool winds
- Dampness
- Cold water
- Working on snowy or icy surfaces
- Wind chill factors

Wind chill is the result of temperature plus wind speed.

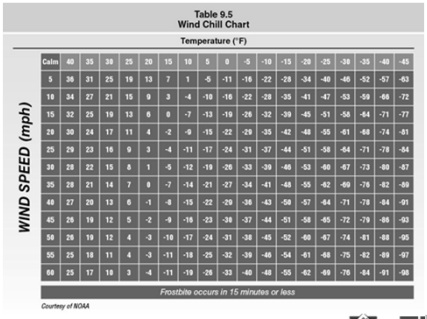


Table 9.5
Wind Chill Chart

Temperature (°F)

WIND SPEED (mph)	Calm	40	35	30	25	20	15	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45
5	36	31	25	19	13	7	1	-5	-11	-16	-22	-28	-34	-40	-46	-52	-57	-63
10	34	27	21	15	9	3	-4	-10	-16	-22	-28	-35	-41	-47	-53	-59	-66	-72
15	32	25	19	13	6	0	-7	-13	-19	-26	-32	-39	-45	-51	-58	-64	-71	-77
20	30	24	17	11	4	-2	-9	-15	-22	-29	-35	-42	-48	-55	-61	-68	-74	-81
25	29	23	16	9	3	-4	-11	-17	-24	-31	-37	-44	-51	-58	-64	-71	-78	-84
30	28	22	15	8	1	-5	-12	-19	-26	-33	-39	-46	-53	-60	-67	-73	-80	-87
35	28	21	14	7	0	-7	-14	-21	-27	-34	-41	-48	-55	-62	-69	-76	-82	-89
40	27	20	13	6	-1	-8	-15	-22	-29	-36	-43	-50	-57	-64	-71	-78	-84	-91
45	26	19	12	5	-2	-9	-16	-23	-30	-37	-44	-51	-58	-65	-72	-79	-86	-93
50	26	19	12	4	-3	-10	-17	-24	-31	-38	-45	-52	-60	-67	-74	-81	-88	-95
55	25	18	11	4	-3	-11	-18	-25	-32	-39	-46	-54	-61	-68	-75	-82	-89	-97
60	25	17	10	3	-4	-11	-19	-26	-33	-40	-48	-55	-62	-69	-76	-84	-91	-98

Frostbite occurs in 15 minutes or less

Courtesy of NOAA

Cold emergencies can be prevented by taking precautions.

- Being active
- Rehabbing in a warm area
- Wearing warn clothing/layers
- Dressing appropriately
- Avoiding cold beverages

CPC may cause claustrophobia and the chemical hazards that responders face could cause anxiety.

CPC and other types of encapsulating PPE are confining

- Can be debilitating
- Training will build confidence

If responder is still uncomfortable, emergency response CPC may not be suitable for her/him

Pre- and post-entry evaluations directed by AHJ should be conducted before and after entering the warm or hot zones.

- Vital signs
- Hydration
- Skin
- Mental status
- Medical history

9–156

AHJ requires exposure records be kept with medical records for personnel who work near any hazardous chemicals.

Exposure records include

- Type of exposure
- Length of exposure
- Description of PPE used
- Type of decon used and any decon solutions
- On scene and follow-up medical attention and/or assistance

9–157

REVIEW QUESTION

What types of PPE related stresses are hazmat responders likely to experience?

9–158

Learning Objective 5

Describe procedures for safely using PPE.

9–159

Learning how to safely use PPE will increase the responder's comfort and proficiency.

9–160

Before donning PPE, it is necessary to conduct a pre-entry inspection.

Visual inspection → Confirm pressure test completion dates

Operational check of PPE components

- Breathing apparatus
- All zippers and closures
- Valves
- Communications equipment
- Any equipment taken or used in hot zone

9–161

Remember emergency and safety procedures when entering an IDLH atmosphere.

- Use the "buddy system"
  - Work in teams of two inside IDLH area
  - Ensure at least two equally trained and equipped responders (backup personnel) are outside IDLH area in case of need for rescue
- Operate within accountability systems and know evacuation and escape procedures

9–162

Before entering the hot zone, responders will receive a safety briefing.

- Incident status
- Identified hazards
- Description of site
- Tasks to be performed
- Expected duration of tasks
- Escape route or area of refuge
- PPE and health monitoring requirements
- Incident monitoring requirements
- Notification of identified risks
- Communication procedures, including hand signals

9–163

NOTE

After using PPE at an incident, fill out any associated reports or documentation as required by the AHJ.

9–164

When wearing a limited air supply, the PPE user must know the estimated time for each task to remain safe.

- Walk to and return from incident
- Decon
- Work time
- Safety time

9–165

Local agencies may need to stock different sizes and volumes of SCBA air cylinders to ensure personnel safety.

Table 9.6
Breathing Air Cylinder Capacities

Rated Duration	Pressure	Volume
30-minute	2,216 psi (15 290 kPa)	45 ft³ (1 270 L) cylinders
30-minute	4,500 psi (31 000 kPa)	45 ft³ (1 270 L) cylinders
45-minute	3,000 psi (21 000 kPa)	66 ft³ (1 870 L) cylinders
45-minute	4,500 psi (31 000 kPa)	66 ft³ (1 870 L) cylinders
60-minute	4,500 psi (31 000 kPa)	87 ft³ (2 460 L) cylinders

• Rated duration does not indicate the actual amount of time that the cylinder will provide air.

9–166

NOTE

A cylinder's service pressure and rating are not a true indication of the overall work time. The one constant is the amount of air the cylinder will contain when it is full.

9–167

Contamination and exposure are two separate hazards common in hazmat incidents.

Contamination
- A condition of impurity resulting from contact or mixture with foreign substance

Exposure
- A hazardous material entered or potentially entered body via routes of entry

9–168

Avoid contamination as best as possible as it increases the risk of exposure.

- Always try to reduce any contact with product
- Avoid walking through and touching product
- Avoid kneeling or sitting on the ground in CPC
- Allowing suit to come in contact with ground may cause suit chafing or abrasion allowing for faster degradation
- Protect monitoring instruments as best as possible

9–169

NOTE

If avoidance is not possible and you need to protect the suit from damage, put something between your suit and the ground/contamination (options include: thick cardboard; rug; visqueen; absorbent pillows, pigs, booms, socks, and pads; knee pads).

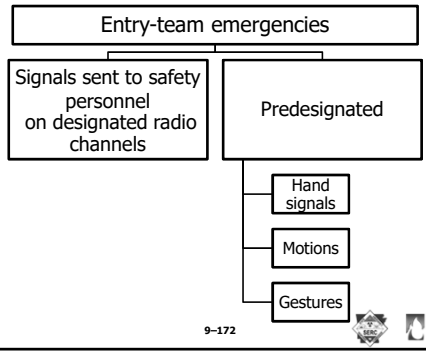
9–170

Some level of communicative capabilities is required for all levels of PPE.

- Communication devices may be integrated into PPE
- Can also use predesignated hand signals, motions, gestures

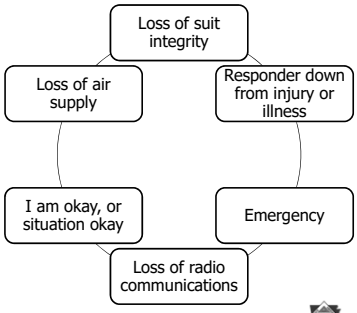
9–171

Planned emergency communication is vital.



9–172

If radio communication is lost, backup communication through hand signals may be used.



9–173

NOTE

Follow hand signals specified by the AHJ.

9–174

During an emergency evacuation situation, communication is crucial.

Notify appropriate personnel

Communicate remaining capabilities of equipment

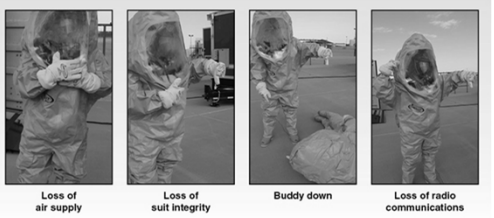
Ensure emergency evacuation signal is audible

Air horn	Radio broadcast

9–175

Backup hand signals should be simple, easy to remember, and distinguishable from a distance.

Table 9.7
Hand Signals



9–176

The donning of PPE can be time consuming and confusing.

You should always train with the protective clothing that you will be using in field

Manufacturer and department recommendations for donning PPE must be followed

9–177

Know the generic PPE donning procedures.

Preselect clearly delineated area in cold zone close to entry point
Ensure area is isolated from distractions, sheltered from elements
Select area large enough to accommodate all personnel
Entry, backup team members medically evaluated based on AHJ procedures
Continue hydration per AHJ 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

9–178

Backless chairs will accommodate responders being donned in PPE with a breathing apparatus.

9–179

Assistants or personnel put PPE on responders so that responders may rest before entering the hot zone.

9–180

Entry and backup team should be donned at the same time so both teams are ready for the entry order.

Entry team	• Safety officer performs final check of all equipment and closures • Allowed to enter hot zone
Backup team	• Left off air and in resting position until called into service • Based on hazards, may be put on air and placed in hot zone to cut travel time if entry team needs assistance

9–181

Upon exit from the hot zone, the entry team is attended to by doffing personnel.

- Entry teams needs decontamination prior to doffing
  - Doffing personnel may wear a lower level CPC
- Entry team will be hot, tired, anxious to remove PPE
  - Doffing personnel should watch for signs and symptoms of heat stress

9–182

There is a generic guide to doffing PPE.

- Personnel wearing PPE should allow assisting personnel to perform work
- To avoid cross contamination, entry team members only touch inside of PPE; assisting personnel only touch outside of PPE
- Once PPE is removed, zip or store so that inside and outside surfaces cannot touch
- All entry PPE placed in a marked containment
- Respirator facepiece last item removed by user
- Breathing apparatus should be isolated and marked for decontamination
- All entry team and support team members must report immediately to rehab

9–183

REVIEW QUESTION

List general steps that should be performed during pre-entry inspection, donning, and doffing PPE.

9–184

Learning Objective 6

Identify procedures for inspection, storage, testing, maintenance, and documentation of PPE.

9–185

Follow a standard program of inspecting PPE.

Inspect PPE	• On initial receipt • Before and after each use • Periodic inspections by personnel
Inspect respiratory equipment	• Each use • Daily or weekly • Monthly • Annually

9–186

Follow a standard program of maintaining PPE.

Maintain PPE according to

- Manufacturer's recommendations
- NFPA standards
- OSHA requirements

9–187

Store PPE to prevent damage from dust, extreme temperatures, moisture, sunlight, chemicals and impact.

9–188

Proper documentation of PPE maintenance and use is important.

Review inspection, testing, and maintenance logs

- Can show patterns about equipment

AHJ requires documentation after PPE use at incident

- May include PPE inspection forms, contaminated gear forms, deprovisioning forms

9–189

REVIEW QUESTION

Why is it so important for a responder to properly inspect, store, test, maintain, and document use of PPE and respiratory equipment?

9–190

Chapter 9: Implementing the Response: Personal Protective Equipment Answers
Key Terms

1. **Powered Air-Purifying Respirator (PAPR)** – Motorized respirator that uses a filter to clean surrounding air, then delivers it to the wearer to breathe; typically includes a headpiece, breathing tube, and a blower/battery box that is worn on the belt.
2. **Immediately Dangerous to Life and Health (IDLH)** – Description of any atmosphere that poses an immediate hazard to life or produces immediate irreversible, debilitating effects on health; represents concentrations above which respiratory protection should be required. Expressed in parts per million (ppm) or milligrams per cubic meter (mg/m^3); companion measurement to the permissible exposure limit (PEL).
3. **Supplied Air Respirator (SAR)** – Atmosphere-supplying respirator for which the source of breathing air is not designed to be carried by the user; not certified for fire fighting operations. *Also known as* Airline Respirator System.
4. **Emergency Breathing Support System (EBSS)** – Escape-only respirator that provides sufficient self-contained breathing air to permit the wearer to safely exit the hazardous area; usually integrated into an airline supplied-air respirator system.
5. **Air-Purifying Respirators (APRs)** – Respirator that removes contaminants by passing ambient air through a filter, cartridge, or canister; may have a full or partial facepiece.
6. **Flame-Resistant (FR)** – Material that does not support combustion and is self-extinguishing after removal of an external source of ignition.
7. **Liquid Splash-Protective Clothing** – Chemical-protective clothing designed to protect against liquid splashes per the requirements of NFPA® 1992, *Standard on Liquid Splash-Protective Suits for Hazardous Chemical Emergencies*; part of an EPA Level B ensemble.
8. **Encapsulating** – Completely enclosed or surrounded, as in a capsule.
9. **Vapor-Protective Clothing –** Gas-tight chemical-protective clothing designed to meet NFPA® 1991, *Standard on Vapor-Protective Suits for Hazardous Chemical Emergencies*; part of an EPA Level A ensemble.
10. **Permeation** – Process in which a chemical passes through a protective material on a molecular level.
11. **Chemical Degradation** – Process that occurs when the characteristics of a material are altered through contact with chemical substances.
12. **Penetration** – Process in which a hazardous material enters an opening or puncture in a protective material. *See* Routes of Entry.
13. **Level A PPE** – Highest level of skin, respiratory, and eye protection that can be given by personal protective equipment (PPE), as specified by the U.S. Environmental Protection Agency (EPA); consists of positive-pressure self-contained breathing apparatus, totally encapsulating chemical-protective suit, inner and outer gloves, and chemical-resistant boots.
14. **Level B PPE** – Personal protective equipment that affords the highest level of respiratory protection, but a lesser level of skin protection; consists of positive-pressure self-contained breathing apparatus, hooded chemical-protective suit, inner and outer gloves, and chemical-resistant boots.
15. **Level C PPE** – Personal protective equipment that affords a lesser level of respiratory and skin protection than levels A or B; consists of full-face or half-mask APR, hooded chemical-resistant suit, inner and outer gloves, and chemical-resistant boots.
16. **Level D PPE** – Personal protective equipment that affords the lowest level of respiratory and skin protection; consists of coveralls, gloves, and chemical-resistant boots or shoes.
17. **Heat Stroke** – Heat illness in which the body's heat regulating mechanism fails; symptoms include (a) high fever of 105° to 106° F (40.5° to 41.1° C), (b) dry, red, hot skin, (c) rapid, strong pulse, and (d) deep breaths or convulsions. May result in coma or even death. *Also known as* Sunstroke.
18. **Heat Exhaustion** – Heat illness caused by exposure to excessive heat; symptoms include weakness, cold and clammy skin, heavy perspiration, rapid and shallow breathing, weak pulse, dizziness, and sometimes unconsciousness.
19. **Heat Cramps** – Heat illness resulting from prolonged exposure to high temperatures; characterized by excessive sweating, muscle cramps in the abdomen and legs, faintness, dizziness, and exhaustion.
20. **Heat Rash** – Condition that develops from continuous exposure to heat and humid air; aggravated by clothing that rubs the skin. Reduces the individual's tolerance to heat.

21. **Trench Foot** – Foot condition resulting from prolonged exposure to damp conditions or immersion in water; symptoms include tingling and/or itching, pain, swelling, cold and blotchy skin, numbness, and a prickly or heavy feeling in the foot. In severe cases, blisters can form, after which skin and tissue die and fall off.
22. **Frostbite** – Local tissue damage caused by prolonged exposure to extreme cold.
23. **Hypothermia** – Abnormally low body temperature.

True/False

1. True.
2. False
3. False
4. True.
5. True.
6. False
7. True.
8. True.
9. False
10. False

Fill in the Blank

1. moisture
2. insulation, cold
3. heat stroke
4. fluid consumption
5. high winds
6. warm clothing
7. training
8. monitoring, PPE
9. years

Picture Identification

Part I: Personal Protective Clothing
1. Flame-resistant clothing
2. Vapor-protective clothing
3. Proximity suit
4. Body armor
5. Liquid-splash clothing
6. Structural fire fighting clothing

Part II: Structural Fire Fighting Clothing
(Photo: WB 9.13)

Part III: Permeation, degradation, and penetration
1. Penetration
2. Permeation
3. Degradation

Matching

Part I: Types of respiratory equipment

1. A
2. C
3. B
4. A
5. B
6. A
7. C
8. B
9. C
10. B
11. C
12. A

Part II: Use of Respiratory Equipment

1. D
2. C
3. A
4. E

Short Answer

1. *Answers should include the following:*
   - Breathing apparatus
   - All zippers and closures
   - Valves
   - Communications equipment
   - Any equipment that will be taken or used in the hot zone
2. *Answers should include the following:*
   - Walk to incident
   - Return from incident
   - Decon
   - Work time
   - Safety time (extra time allocated for emergency use)
3. *Answers may vary; students should include three of the following*:
   - Always try to reduce any contact with the product
   - Avoid walking through and touching the product whenever possible
   - Do not kneel or sit on the ground in CPC, if possible
   - Avoidance is paramount, but allowing a suit to come in contact with the ground may cause chafing or abrasion on the suit allowing for faster suit degradation
   - Protect monitoring instruments as best as possible

   Answers should include the following:
   - Notify appropriate personnel (Entry Team Leader, Hazmat Safety Officer)
   - The remaining capabilities of equipment

5. *Answers should include the following:*
   Entry team goes to the entry access point
   Safety officer performs final check of all equipment and closures before teams are allowed to enter hazard area
   Backup team should be left off air and in resting position until such a time that it may be called into service
   Based on the hazards and chemicals involved, backup team may be put on air and placed within the hot zone to reduce the travel time should the entry team need assistance with rapid exit
6. *Answers may vary; students should include one of the following from each part:*
   Responder should allow assisting personnel to perform the doffing work
   Responder should only touch the inside of garments and never the outside
   Assisting personnel should only touch the outside of the garments
   Last item removed from responder should be respirator facepiece and it should be removed by the responder

Scenario

Scenario #1

1. 124
2. *Answer should include the following in any order:*
   TOXIC; may be fatal if inhaled or absorbed through skin.
   Fire will produce irritating, corrosive and/or toxic gases.
   Contact with gas or liquefied gas may cause burn, severe injury, and/or frostbite.
   Runoff from fire control may cause pollution.
3. *Answer should include the following in any order:*
   Wear positive-pressure self-contained breathing apparatus (SCBA).
   Wear chemical protective clothing which is specifically recommended by the manufacturer. It may provide little or no thermal protection.
   Structural firefighters' protective clothing provides limited protection in fire situations ONLY; it is not effective in spill situations.

Scenario 2

1. The material is flammable.
2. Propane
3. *Answers should include the following in any order:*
   EXTREMELY FLAMMABLE.
   Will be easily ignited by heat, sparks, or flames.
   Will form explosive mixtures with air.
   Vapors from liquefied gas are initially heavier than air and spread along ground.
   Vapors may travel to source of ignition and flash back.
   Cylinders exposed to fire may vent and release flammable gas through pressure relief devices.
   Containers may explode when heated.
   Ruptured cylinders may rocket.
4. *Answer should include the following in any order:*
   Wear positive pressure SCBA.
   Structural firefighters' protective clothing will only provide limited protection.
   Always wear thermal protective clothing when handling refrigerated/cryogenic liquids.

Scenario 3

1. Phenol solution
2. 153
3. *Answer should include the following in any order:*

   Wear positive-pressure SCBA.

   Wear chemical protective clothing which is specifically recommended by the manufacturer. It may provide little or no thermal protection.

   Structural firefighters' protective clothing provides limited protection in fire situations ONLY; it is not effective in spill situations.

Hazardous Materials for First Responders
Fifth Edition

Chapter 10 — Implementing the Response: Decontamination

HAZARDOUS MATERIALS FOR FIRST RESPONDERS
FIFTH EDITION

IFSTA

Learning Objective 1

Define the different types of decontamination that may be used at a hazmat incident.

10–1

Decontamination is essential to ensure the safety of emergency responders and the public.

Decontamination (decon) must be considered at any hazardous materials or terrorism incident

Emergency decontamination should be established at all hazmat incidents

10–2

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

Two types of contamination

- **Direct contamination** Occurs through contact with source of contamination
- **Cross contamination** (*secondary contamination*) Occurs without direct contact with source

10–3

Contaminants may be solids, liquids, or gases.

Hazards

- Vary depending on the material
- May be divided into three types
  - Chemical
  - Physical
  - Biological

10–4

Contamination can be external or internal.

External	Internal
On outside of body or PPE	On inside of body

10–5

Decontamination (decon) or contamination reduction is the process of removing hazardous materials.

Decon

- Prevents the spread of contaminants beyond a specific area
- Reduces contamination to levels that are no longer harmful
- Prevents possible exposure to hazardous materials by removing contaminants

10–6

People, animals, or the environment can come in contact with a material without it being transferred.

This process is called *exposure*

Decontamination may not be necessary if an individual has been ***exposed*** to a hazardous material rather than ***contaminated*** by it

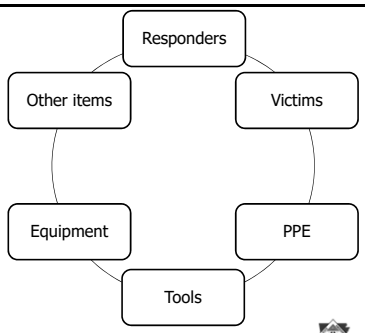
10–7

Decontamination operations must be considered at any hazardous materials or terrorism incident.

- To ensure safety of emergency responders and the public
- To minimize potentially harmful exposures
- To reduce or eliminate spread of contaminants

10–8

Decontamination must be considered at hazmat/WMD incidents.



10–9

Decontamination removes hazardous materials from victims, responders, or other items.

Courtesy of Boca Raton Fire Rescue

10–10

Everyone and everything in the hot zone is subject to contamination.

In the hot zone, everyone and everything is subject to contact with hazardous materials and potential contamination

Anything that goes into the hot zone passes through a decon area when leaving the zone

10–11

Know the four main types of decontamination.

Gross decontamination	• Surface contamination reduced as quickly as possible
Emergency decontamination	• Contaminant removed from victim as quickly as possible *without regard for the environment or property protection*
Technical decontamination	• Chemical or physical methods used to thoroughly remove contaminants from responders and equipment
Mass decontamination	• Large numbers of people decontaminated in fastest possible time • Reduces surface contamination to safe level

10–12

Decontamination can also provide victims with psychological assurance.

Potential exposure to hazardous materials can cause psychologically-based symptoms even if not actually exposed

Conducting decontamination can reduce or prevent this

10–13

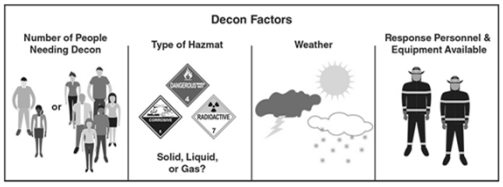
Continually assess the effectiveness of any decontamination operation.

Important to continually assess

If selected method is not working, a different technique must be tried

10–14

The type of decontamination operations conducted at an incident are determined by a variety of factors.



10–15

Performing decon at terrorist incidents may require changes to procedures, even for experienced responders.

Hazmat/WMD incidents may involve large numbers of people who must be

- Quickly assessed for injury or exposure
- Passed through a decon corridor for treatment or safe sheltering away from the incident (mass decon)

10–16

Terrorist incidents must be treated as crime scenes.

Clothing, equipment, and contaminated materials must be

- Protected as evidence
- Handled according to local policies/procedures

10–17

NOTE

Responders must be familiar with their organization's decon policies and procedures and how decon operations are implemented within the AHJ's incident command system.

10–18

Regardless of incident variables, basic principles of any decontamination operation can be easily summarized.

Get it off → Keep it off → Contain it

10–19

Before initiating decontamination, consider the answers to these questions.

Do victims need to be decontaminated immediately, or can they wait?

Is it safe to conduct decontamination?

Is there a safe place to conduct decon?

What alternative decon methods are available?

(Cont.)

10–20

Before initiating decontamination, consider the answers to these questions.

Are there adequate resources?

If not, can other resources be obtained in a timely fashion?

What is the time limit available to conclude decon before victims deteriorate further?

Is the equipment you are attempting to decontaminate going to be useable again and/or is it more cost effective to simply dispose of it?

Does decon save money, or add value?

10–21

REVIEW QUESTION

What is the purpose of decontamination?

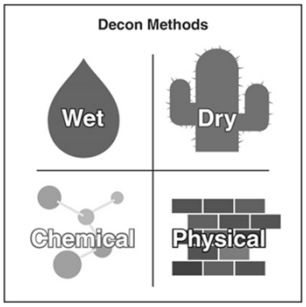
10–22

Learning Objective 2

Identify decontamination methods.

10–23

Decontamination methods can be divided into four broad categories.



Wet or dry

Physical or chemical

10–24

Decontamination methods vary in their effectiveness for removing different substances.

- The most effective means of decon may be simple — removal of contaminated outer clothing or PPE
- Flushing the contaminated surface with water is often effective at removing or sufficiently diluting material to a safe level
- Removing contaminated outerwear and flushing are usually sufficient for emergency and mass decontamination — technical decon requires additional efforts to thoroughly remove contaminants

10–25

Technical decontamination requires additional effort to meet the objective of removing all contaminants.

Technical decon involves washing with water and some type of soap, detergent, or chemical solution

The decision whether to perform emergency or technical decon is determined based on

- Hazardous materials involved
- Urgency in removing victim

10–26

Wet and dry methods are categorized by whether they use water or other resources.

- Wet methods
  - Washing surface with solutions
  - Flushing with water from hose or safety shower
- Dry methods
  - Scraping
  - Brushing
  - Absorption

10–27

Wet decontamination methods may require collecting runoff water in liquid- retaining (containment) devices

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

Analyze water for treatment and disposal

Dispose of water and residue according to applicable laws and regulations

Notify and consult proper authorities during this process

10–28

Wet decontamination methods may be difficult or impractical.

In some cases wet methods are difficult or impractical due to environmental or weather conditions

But life safety MUST take precedence over environmental considerations

10–29

Dry decontamination methods may simple or more involved.

Simple methods include

- Remove contaminated clothing and place into a suitable plastic bag or recovery drum
- Allow the contamination to evaporate

More involved methods include

- Vacuum or brush a powder or dust from a surface
- Scrape off a material
- Use sticky tape or sticky pad

10–30

Dry methods have some advantages.

Dry methods

- Do not create large amounts of contaminated runoff
- May be accomplished by systematic removal of disposable PPE while avoiding contact with contaminants
- May be used during cold weather operations when wet methods difficult to implement
- Use caution to prevent material becoming airborne

10–31

Dry materials can remove liquid chemicals by absorption.

Materials for absorption may include

- Clay
- Sawdust
- Flour
- Dirt
- Fuller's earth
- Tissue paper
- Carbon
- Silica gel
- Paper towels
- Sponges

Once used, these materials must be

- Treated as contaminated waste
- Disposed of accordingly

10–32

Dry decontamination can make use of sorbent powders or similar materials.

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

10–33

Physical methods do not change the material chemically.

Physical methods

- Remove the contaminant without changing the material chemically
- The contaminant is contained for disposal

Examples of physical decon methods

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

10–34

Chemical methods make the contaminant less harmful by changing it through a chemical process.

Examples of chemical decontamination methods

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

Be careful to avoid creating additional hazards by introducing other chemicals to the process

10–35

REVIEW QUESTION

Give examples of the wet, dry, physical, and chemical methods of decontamination.

Learning Objective 3

Define gross decontamination.

Gross decontamination is intended to significantly reduce surface contamination as quickly as possible.

Traditionally accomplished by

Mechanical removal of the contaminant

Or

Initial rinsing from handheld hose lines, emergency showers, or other nearby sources of water at hazmat incidents

Gross decon is recommended at all incidents involving exposure to potentially hazardous substances.

Gross decon may be accomplished by

- 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 SOPs
- It is recommended that structural firefighter protective clothing be machine washed in designated machines back at the station
- Personnel should shower with soap and water thoroughly as soon as possible, even if wet methods of decon are used at the emergency incident scene

Perform gross decontamination in multiple situations with various individuals.

- Emergency responders exposed to smoke or products of combustion, before leaving incident scene
- Responders before undergoing technical decontamination
- Victims during emergency decontamination
- Persons requiring mass decontamination

Gross decon has advantages and disadvantages, and requires follow-up.

An advantage is	It is conducted in the field, so reduction of contaminants is immediate
A disadvantage is	Although it may remove the worst surface contamination, it may not remove *all* contaminants
Gross decon	Is not complete decon
	Should be followed by more thorough decontamination

REVIEW QUESTION

In what situations should gross decon be performed?

Learning Objective 4

Explain processes for emergency decontamination.

The goal of emergency decontamination is to remove contaminants quickly.

- Remove the threatening contaminant as quickly as possible
- Emergency decon may be necessary for both victims and rescuers
- If victims or rescuers contaminated, remove clothing (or PPE) and wash quickly
- Victims needing immediate medical treatment cannot wait for establishment of formal decon corridor

Emergency decontamination operations are needed in various situations.

For example

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

Emergency decontamination has both advantages and limitations.

Advantages	Limitations
• Fast to implement • Requires minimal equipment (usually just a water source) • Reduces contamination quickly • Does not require a formal contamination reduction corridor or decon process	• Removal of all contaminants may not occur; more thorough decon must follow • Emergency decontamination can harm the environment • Measures to protect the environment are important, but should not delay lifesaving actions • Eradicating a life-threatening situation far outweighs negative effects

Seemingly normal incidents may involve hazardous materials.

Emergency responders may become contaminated before they realize the danger

If this occurs, withdraw immediately and follow local procedures for emergency decon

Should air supply allow, responders should remain isolated until personnel with proper expertise and monitoring equipment ensures they have been adequately decontaminated

Emergency decontamination requires a safe area and safe procedures.

Responders conducting emergency decon should

- Wear appropriate PPE
- Always avoid contacting contaminants or potentially contaminated surfaces

If responders contact contaminants

- They may need to decontaminate themselves

Procedures may differ

- Depending on circumstances
- Hazards present at scene

10–48

Seemingly normal incidents may involve hazardous materials.

Emergency responders may become contaminated before they realize what the situation really is

- Withdraw immediately
- Follow local procedures for emergency decontamination

10–49

REVIEW QUESTION

What are the advantages of emergency decon?

10–50

Learning Objective 5

Explain processes for technical decontamination.

10–51

Technical decon uses chemical or physical methods.

Used to

- Thoroughly remove or neutralize contaminants from responders' PPE and equipment
- On incident victims in non-life-threatening situations

Courtesy of the U.S. Air Force, photo by Chiaki Iramina

10–52

Operations Level responders involved in technical decontamination must be supervised.

Operations Level responders must be under the guidance of

- A hazmat technician
- SOP/Gs
- Or an allied professional

Responders must be familiar with the AHJ procedures

- Positions
- Roles
- Responsibilities

10–53

Operations Level responders perform supervised duties.

- Protect themselves by dressing in appropriate PPE
- Establish a water supply
- Set up the decon corridor
- Establish perimeters
- Perform physical decon activities such as scrubbing, washing, spraying
- Assist in undressing/removal of PPE or clothing of individuals going through decon
- Assist individuals going through decon
- Perform other duties per SOP/Gs

Technical decontamination is usually conducted within a formal decon line or corridor.

Type and scope determined by contaminants

Resources for determining procedures may include

- "First Aid" section of the safety data sheet(s) (SDS)
- Emergency response centers (such as CHEMTREC, CANUTEC, SETIQ)
- Container information labels
- Pre-incident plans
- Technical experts
- *ERG*
- Poison control centers
- Other books, reference sources, computer programs, and/or data bases

Monitoring should be conducted to determine whether decon operations are effective

Equipment used in a hazmat incident may need to be disposed of.

If equipment contaminated

Must be removed from service

Properly contained before disposal

Various technical decontamination techniques may be used.

- Absorption
- Adsorption
- Brushing and scraping
- Chemical degradation
- Dilution
- Evaporation
- Isolation and disposal
- Neutralization
- Sanitization, disinfection, and sterilization
- Solidification
- Vacuuming
- Washing

Different technical decon techniques have advantages and disadvantages.

Table 10.1
Advantages and Disadvantages of Technical Decon Techniques

Method	Advantages	Disadvantages
Absorption	• Many absorbent materials are inexpensive and readily available • Can be used as part of dry decon operations • Effective on flat surfaces	• Do not alter the hazardous material • Ineffective for decontaminating protective clothing and vertical surfaces • Disposal of contaminated absorbent materials may be problematic and expensive • Absorbent materials may increase in weight and/or volume as they absorb the hazmat • Absorbent materials must be compatible with the hazardous material
Adsorption	• Contains the hazardous material better than absorbent materials • Transportation of materials to disposal is simplified • Off-gasing (release of vapors/gases) is effectively reduced • Adsorptive materials do not swell	• Process can generate heat • Application typically limited to remediation of shallow liquid spills • Adsorptive materials are expensive • Adsorptive material must be compatible with the hazardous material (they are product specific)

(Cont.)

Different technical decon techniques have advantages and disadvantages.

Chemical Degradation	• Can reduce cleanup costs • Reduces risk posed to the first responder when dealing with biological agents • Often utilizes commonly available, inexpensive materials such as bleach, isopropyl alcohol, or baking soda • Utilizes products that are readily available	• Takes time to determine the right chemical to use (which should be approved by a chemist) and set up the decon process • Can cause violent reactions if done incorrectly and may create heat and toxic vapors • Rarely used to decontaminate people
Dilution	• Lessens the degree of hazard present by reducing the concentration of the hazardous material • Easy to implement (water is usually readily available) • Is very effective in many circumstances requiring decon • Can be used to decon large pieces of equipment/apparatus	• Can't be used on materials that react adversely to water • May be problematic in cold weather • May create large amounts of contaminated runoff • May be impractical because of the amount of water required for effective dilution
Disinfection	• Kills most of the biological organisms present • Can be used on site • Can be accomplished using a variety of chemical or antiseptic products • Disinfecting agent may be as simple as antibacterial soap or detergent	• Limited to biological decon only • May be difficult to decon large pieces of equipment/apparatus • Disinfecting agent may be toxic or harmful

Continued

(Cont.)

Different technical decon techniques have advantages and disadvantages.

Method	Advantages	Disadvantages
Evaporation	• No additional materials necessary • No runoff collection necessary • No (or very limited) expense incurred	• Applicable for a very limited number of chemicals • Generally limited to decon of tools and equipment, not people • May be dramatically affected by weather conditions (including wind, temperature, humidity, and rain) • Hazardous vapors may travel and cause problems • May require a long time to complete • May not be acceptable method to use depending on applicable laws and regulations
Isolation and Disposal	• Isolation can be quick and effective • Easily achieved with containers such as isolation drums, heavy plastic bags, and other means of containment	• Disposal and transport costs may be extremely high • May require replacement of equipment and PPE that cannot be decontaminated and placed back in service
Neutralization	• Chemically alters the hazardous material to reduce the degree of hazard present • Effective on most corrosives and some poisons • Neutralizing agents are readily available (soda ash, vinegar)	• May be very difficult to successfully implement • Rarely done on living tissue • May require large quantities of neutralizing agents • May create violent chemical reaction including the release of heat and hazardous vapors • Preplanning is usually necessary

(Cont.)

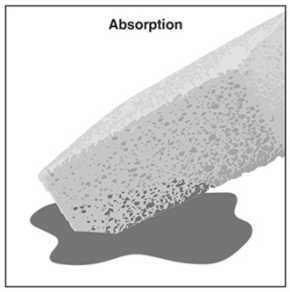
10–60

Different technical decon techniques have advantages and disadvantages.

Solidification	• Solids are easier to contain than liquids and gases • Reduces the amount of vapor production and off gasing • Easier to clean up	• Requires specialized materials to implement
Sterilization	• Kills all microorganisms present	• Difficult or impossible to do onsite
Vacuuming	• Effective at removing dust and particulates • Effective indoors • Dry method, useful for cold weather operations in some situations	• Requires specialized vacuums equipped with hepa filters • May require high risk, negative air containment for decon area • Removing liquid chemical contamination requires special equipment • May require additional decon procedures to ensure complete decontamination (for example, washing) • Can't be used to decontaminate materials that react adversely to contact with water • May be problematic in cold weather • May create large amounts of contaminated runoff
Washing	• Quick and easy to implement (water is usually readily available) • Soap is readily available and inexpensive • Typically more effective than dilution alone • Is very effective in many circumstances requiring decon • Can be used to decon large pieces of equipment/apparatus	• Can't be used to decontaminate materials that react adversely to contact with water • May be problematic in cold weather • May create large amounts of contaminated runoff

10–61

Absorption is the process where liquid contaminants are absorbed into an absorbent material.



Many absorbents are

- Inexpensive
- Readily available
- Expensive to dispose of once contaminated

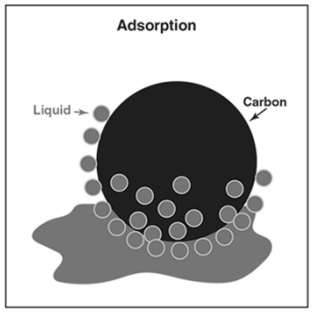
10–62

NOTE

The use of soil as an absorbent is not recommended by many experts.

10–63

In adsorption, contaminants are bound to the surface of an adsorbent such as charcoal or carbon.



10–64

Adsorption is the process in which a hazardous liquid interacts with the surface of a sorbent material.

Adsorbents tend to not swell like absorbents

It is important to make sure adsorbent is compatible with the hazardous material

10–65

Brushing and scraping may remove large particles of contaminant.

Brushing and scraping alone usually not sufficient decontamination

This method is used before other types of decon

Courtesy of Bldg. Capt. David W. Ford

10–66

Chemical degradation changes the chemical structure of a hazardous material.

Example: household liquid bleach

- Commonly used to neutralize spills of etiological agents
- Interaction of bleach with agent
  - Kills the dangerous germs
  - Makes the material safer to handle

10–67

Dilution uses water to flush contaminants and dilutes water-soluble hazardous materials to safe levels.

Advantages	• Accessibility • Speed • Economy of using water
Disadvantages	• Depending on material, water may cause a reaction — create even more serious problems • Runoff from process is still contaminated — may have to be confined and disposed of properly • Amount of water needed for dilution may be impractical

10–68

Evaporation is the process of turning a liquid into a gas.

Some hazardous materials evaporate quickly and completely

Decontamination sometimes accomplished by simply waiting for materials to evaporate

Evaporation used for

- Gaseous materials with high vapor pressures
- Tools and equipment when long exposure time is not a safety issue

10–69

Evaporation can be used for decon of gaseous materials.

Courtesy of Rich Mahaney

10–70

Isolation and disposal may be part of the decon process.

All equipment that cannot be sufficiently decontaminated must be disposed

All spent solutions and wash water must be collected and disposed

Disposal of equipment may be easier than decontaminating it

Disposal can be very costly in circumstances where large quantities of equipment have been exposed

10–71

Neutralization changes the pH of a corrosive material.

Neutralization

- Raises or lowers the pH towards 7 (neutral) on the pH scale
- Should not be performed on living tissue

10–72

Sanitization, disinfection, or sterilization can render etiological agents harmless.

Sanitization	• Reduces the number of microorganisms to a safe level
Disinfection	• Kills most microorganisms present • Can use a variety of chemical or antiseptic products • Most first responders are familiar with disinfection procedures used to kill bloodborne pathogens
Sterilization	• Kills all microorganisms present • Normally accomplished with chemicals, steam, heat, or radiation

10–73

Sterilization of tools may be necessary before they are returned to service

This process is usually impossible or impractical to do in most onsite decon situations

Such equipment will normally be disinfected on the scene and then sterilized later

10–74

Solidification turns a hazardous liquid into a solid.

Solidification is a process that

- Chemically treats a hazardous liquid
- Turns the liquid into a solid
- Is not used for personnel decontamination

10–75

Vacuuming pulls solid materials from surfaces.

Vacuuming	Regular vacuums
Uses high efficiency particulate air (HEPA) filter vacuums	Are not used
Pulls solids from surfaces—fibers, dusts, powders, particulates	Filters are not fine enough to catch all material

10–76

Washing is a wet method that involves prepared solutions of soap or other surfactants.

Washing involves prepared solutions of soap or other surfactants

After washing, rinse with plain water

Runoff water may need to be contained and disposed of properly

Courtesy of FEMA News Photos, photo by Jocelyn Augustino

10–77

Technical decontamination for ambulatory people usually takes place in decon corridors.

Ambulatory victims are able to

- Understand directions
- Talk
- Walk unassisted

Technical decontamination corridors

- Are typically designed for ambulatory persons
- May be set up for wet or dry decontamination methods
- Vary in number of stations, depending on situation

Technical decontamination

- May be as simple as washing one's hands and face with soap and water

Table 10.2 provides a sample technical decon checklist.

Table 10.2
Sample Decon Checklist

Date: **Location:**

- ☐ Initial briefing from the team leader
- ☐ Incident profile
- ☐ Decon solution and method
- ☐ PPE

Personnel Assignments

Decon Officer

[ ] Identified by vest

- ☐ All personnel monitored by Medical Branch

Decon Site Selection Criteria

- ☐ Decon is located in Warm Zone at exit from Hot Zone
- ☐ Decon area located uphill/upwind from Hot Zone
- ☐ Decon area level or sloped toward Hot Zone
- ☐ Water supply available

Decon Site Setup

- ☐ Area clearly marked with traffic cones and barrier tape to be secure against unauthorized entry
- ☐ Entry and exit points marked
- ☐ Emergency corridor established and clearly marked
- ☐ Runoff contained (tarp, plastic sheeting, dikes)
- ☐ Gross decon shower(s) setup
- ☐ Water supply established
- ☐ Containment basins and pools arranged in proper order
- ☐ Disposal containers in place for PPE and equipment drop
- ☐ Decon solutions mixed
- ☐ Brushes, hand sprayers, hoses and equipment in place
- ☐ Tool drop set up
- ☐ Spare SCBA cylinders available
- ☐ Relief personnel available

Branch Officers Briefing

- ☐ Preparation of branch status report
- ☐ Evaluation of branch readiness for mitigation plan

Entry/Decon Operations

- ☐ Decon and entry personnel briefed on hazards
- ☐ Emergency procedures and hand signals reviewed and understood
- ☐ Decon and entry personnel briefed on decon procedures
- ☐ Decon corridor complete
- ☐ Decon personnel on air
- ☐ Monitored for adequate relief personnel

Termination

- ☐ Disposable/contaminated materials isolated, bagged, and containerized
- ☐ All containers sealed, marked, and isolated
- ☐ All team equipment cleaned and accounted for

Source: Department of Fire Services, Office of Public Safety, Commonwealth of Massachusetts.

Technical decon for nonambulatory victims is a more detailed process.

Nonambulatory victims

- Are civilians or responders who are unconscious, unresponsive, or unable to move unassisted
- May be more seriously injured
- Need assistance being moved to a place for decon
- May have to remain in place if sufficient personnel not available to remove them from hot zone

(Cont.)

Personnel may need to do all or most of the technical decon process for nonambulatory victims.

Aim is to thoroughly decontaminate individuals before transferring to EMS

REVIEW QUESTION

What are the differences between technical decon for ambulatory versus nonambulatory victims?

Learning Objective 6

Explain processes for mass decontamination.

Mass decon is initiated to expedite decon of large numbers of people.

Courtesy of David Lewis

10–84

Mass decontamination is the process of quickly reducing or removing contaminants from multiple persons.

Mass Decontamination

- Used in potentially life-threatening situations
- Initiated when number of victims and time constraints does not allow in-depth decontamination process
- Has the goal of doing the greatest good for the greatest number of people
- Should be a part of overall emergency response plan for all agencies

10–85

The scene of an incident requiring mass decon may be chaotic and difficult to control.

To combat the chaos, communicate with victims using

- Hand signals
- Signs with pictures
- Apparatus public address systems
- Megaphones or other methods

10–86

Communicate with victims during mass decon.

Direct victims to decon gathering areas and through the process

People may be traumatized and/or suffering from exposures

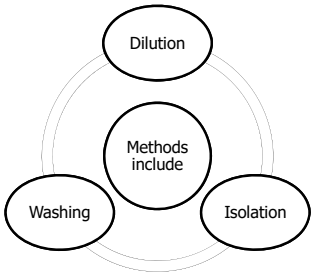
Provide them with simple, specific easily understood directions

Mark decontamination corridors with

- Barrier tape
- Traffic cones
- Other highly visible means

10–87

Know mass decon methods.



10–88

Each mass decon method has advantages and limitations.

Washing with soap-and-water solutions or universal decon solutions will

- Remove many hazardous materials and WMD agents
- But the solutions may not be available in sufficient quantities

Mass decon can be most readily accomplished with simple water shower system

- Dilutes the hazardous product
- Physically washes it away

10–89

Large volumes of water, in a fog pattern, can quickly reduce the level of contamination.

10–90

Mass decon showers should ensure the process physically removes the hazardous material.

Actual showering time is an incident-specific decision

When large numbers of potential victims are involved showering time may be significantly shortened

Time may also depend upon volume of water available the showering facilities

Post-decon monitoring should be used to evaluate effectiveness of decon operations

10–91

WARNING

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

10–92

Do not overlook existing facilities when planning rapid decontamination.

Saving victims' lives could justify activating overhead fire sprinklers even though water damage to a facility might result

Having victims wade and wash in water sources such as public fountains, chlorinated swimming pools, or swimming areas provides an effective, high-volume decontamination technique

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

10–93

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

Contaminated clothing should be isolated for later disposal

10–94

NOTE

You must have an accountability system for all valuables and personal items removed. See the Decontamination Implementation section for more details.

10–95

Many innovations and products can assist in mass decon operations.

- Decon trailers and portable tents (that help alleviate privacy concerns)
- "Bagging and tagging" systems
- Portable water heaters
- Disposable coveralls

10–96

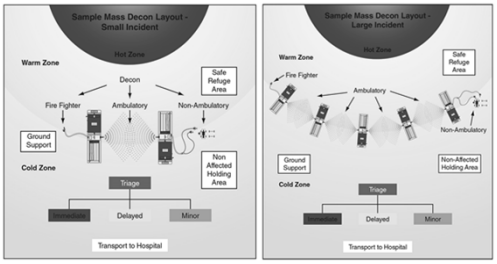
Pre-assembled decon kits may include individual bags, ID tags, and disposable garments.

Courtesy of New South Wales Fire Brigades

Courtesy of New South Wales Fire Brigades

10–97

Apparatus placement may be different for small and large incidents.



Courtesy of Doug Weeks

10–98

More than one decon corridor may be required depending on victim priority.

- Consider factors related both to medical needs and decontamination
- Separate decon corridors may be required
- Provide separate decon line for emergency response personnel
- If possible, separate victims by gender for privacy reasons
- Keep families together

10–99

Nonambulatory victims will not be able to walk through the decon corridor.

Courtesy of the U.S. Air Force. Photo by Tech. Sgt. Todd Prendergast

10–100

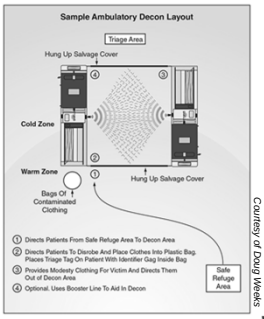
Direct ambulatory victims to an area of safe refuge inside perimeter to await prioritization for decontamination.

Various factors may influence priority of treatment

- Serious medical symptoms such as shortness of breath or chest tightness
- Distance from point of contaminant release
- Exposure to the hazardous material
- Evidence of contamination on clothing or skin
- Conventional injuries such as broken bones or open wounds

10–101

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



Courtesy of Doug Weeks

Apparatus can be effectively placed for emergency or mass decon.

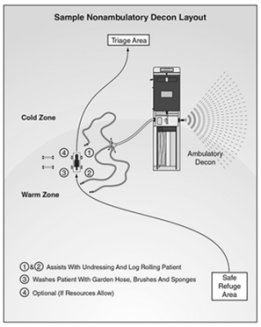
Nonambulatory mass decon victims may be more seriously injured.

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

The apparatus can also be used in both ambulatory and nonambulatory decon corridors.



Courtesy of Doug Weeks

REVIEW QUESTION

What are the differences between mass decon for ambulatory and nonambulatory victims?

Learning Objective 7

Identify victim management activities during decontamination operations.

Know victim management activities.

Victim management activities in incidents requiring decontamination may include

- Triage
- Handling deceased victims

Triage may be necessary for victims in need of medical assistance at a hazardous materials incident.

All victims must undergo decon **before** being transferred to EMS

Deciding to use technical or mass decon depends on

- Type of exposure(s)
- Products involved
- Injuries present
- Other factors

The START medical triage system can help with victim management at chemical agent incidents.

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 atempt 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)

Responders must be prepared for handling deceased victims.

- Deceased victims should usually remain untouched
- AHJ's medical examiner will determine how and when bodies are handled
- Removal of deceased victims from hot zone normally delayed until all viable victims removed
- Always consider ethical issues when removing the deceased; handle them with respect and dignity

(Cont.)

Deceased victims must undergo decon operations before transfer to 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 in order to activate the assistance request
- An on-scene morgue facility may have to be established if the incident involves large numbers of deceased victims

REVIEW QUESTION

What are some considerations when handling deceased victims?

Learning Objective 8

Recognize general guidelines for decontamination operations.

10–114

Know the general guidelines for decontamination operations.

- Ensure technical decon setup is operational before entry personnel enter hot zone
- Begin emergency/mass decon operations quickly; the speed is determined by material and type of incident involved
- Always wear appropriate PPE
- Avoid contacting hazardous materials, including contaminated victims
- Decon operations may begin with initial separation of victims into ambulatory/non-ambulatory and male/female
- Assess all victims believed to have been in hot zone to determine need for decontamination before moving to cold zone

10–115

Both emergency personnel and victims must go through decon.

- Establish clearly designated decon entry points
- The more clothing removed the better; however complete disrobing usually not needed
- Decontaminate all emergency response personnel who have been in hot zone
- Decontaminate emergency responders separately from victims
- Establish medical triage and treatment area just outside decon zone

10–116

Communicate clearly with victims.

Courtesy of New South Wales Fire Brigades

- Direct victims to decon gathering areas as well as through decon process
- Provide clear and easily understood directions
- Victims may be traumatized and/or suffering from exposures
- Provide privacy when possible

10–117

During decon operations, be considerate of victims.

Provide warm water for washing, if possible	If water is cold, allow victims to get wet gradually in order to acclimate to the temperature and avoid cold shock
When decontaminating belongings of victims	Document and preserve them (safeguard their condition) 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

10–118

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

Courtesy of FEMA News Photos; photo by Vin Henderson

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

10–119

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

10–120

REVIEW QUESTION

List general guidelines for decontamination operations.

10–121

Learning Objective 9

Describe decontamination implementation.

10–122

Consider multiple factors when implementing decontamination.

- Site Selection
- Decontamination corridor layout
- Decontamination security considerations
- Cold weather decontamination
- Evidence collection and decontamination
- Evaluating effectiveness of decontamination operations

10–123

Decontamination site selection depends on many factors.

- Wind direction
- Weather
- Accessibility
- Time
- Terrain
- Surface materials
- Lighting and electrical supply
- Drains and waterways
- Water supply

10–124

Consider wind and weather when selecting the decontamination site.

Wind direction

- Site needs to be upwind of the hot zone
- If improperly located downwind, wind currents will blow mists, vapors, powders, and dusts toward responders and victims
- Local weather service can provide assistance in predicting changes in wind direction and weather

Weather

- During cold weather, site should be protected from blowing winds, especially near end of corridor
- Victims should be shielded from cold winds when removing clothing

10–125

Accessibility impacts site selection.

Accessibility of the site

- The site must be away from the hazards, but adjacent to the hot zone so persons exiting hot zone can step directly into decon corridor
- An adjacent site eliminates the chance of contaminating clean areas
- Also puts the decontamination site as close as possible to the actual incident

10–126

Time requirements impact site selection.

The less time it takes personnel to get to and from the hot zone, the longer they can work

Four crucial time periods

Travel time in hot zone	Time allotted to work in hot zone	Travel time back to decon site	Decontamination time

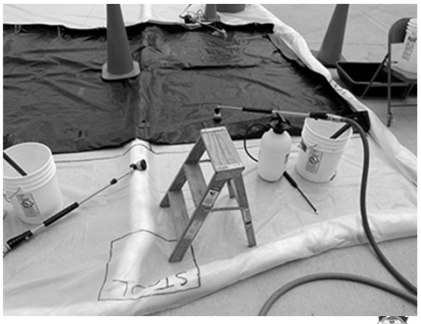
10–127

Also consider terrain and surface material.

- The decon site should be flat or slope toward the hot zone
- Persons leaving the corridor can enter into a clean area
- Finding the perfect topography is not always possible; first responders may have to place some type of barrier to ensure confinement of an unintentional release

10–128

Use flooring during decon.



Use tarps, plastic sheeting, or salvage covers for flooring, even when decon corridor is on a hard surface

10–129

The decon corridor should have adequate lighting to help reduce potential for injury to personnel.

- Selecting a site illuminated by streetlights, floodlights, or other permanent lighting reduces need for portable lighting
- If permanent lighting is unavailable or inadequate, portable lighting will be required
- Ideally, the decon site will have a ready source of electricity
- If electrical source not available, portable generators will be needed

10–130

Water is a major factor when selecting the decon area.

Drains and waterways

- Decon site should NOT be located near storm and sewer drains, creeks, ponds, ditches, and other waterways (unless the sewer system is approved for use as a contained system that can be managed and neutralized)
- If locating site away from water is not possible, a dike can be constructed
- Protect all environmentally sensitive areas if possible, but never delay decon to protect the environment if delay will increase injury

Water supply

- Water must be available at a decon site if wet decon is used

10–131

Preplans should include pre-designated areas for mass decon at various locations.

At locations likely to be targeted by terrorists

- Government buildings
- Stadiums

At hospitals

- To decon large numbers of victims who self-present at emergency rooms

10–132

Establish the decontamination corridor before any work in the hot zone begins.

First responders are often involved with setting up and working in the decontamination corridor

Corridors can be straightforward and require few steps, or more complex requiring a dozen or more steps

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

10–133

Decontamination corridors should ensure privacy.

Decon tents or decon trailers allow more privacy for individuals going through the decon corridor

Be sensitive to needs of women being asked to remove their clothing in front of men

Lawsuits have resulted when women have felt uncomfortable or even humiliated while going through decon

Providing a private, restricted area such as a tent or trailer in which to conduct decon may prevent similar litigation

Use female responders to assist whenever possible when decontaminating women

10–134

Decontamination corridors should keep family units and other caregiver units together.

Courtesy of New South Wales Fire Brigades

10–135

Bag and tag all contaminated clothing and personal effects.

- Place clothing and/or personal effects in labeled bag
- Separate personal effects into clear plastic bags
- Clearly mark bags with name or unique identifying number
- Items may need to be decontaminated before being returned
- Label or mark personal effects for return to proper owners after incident
- Bags containing contaminated clothing should remain on dirty side of the decon line
- Commercial tagging systems may be used for this purpose

10–136

Identify the decontamination corridor with visually recognizable items.

Decontamination corridor may be identified with	• Barrier tape • Safety cones • Other visually recognizable items
Salvage covers or plastic sheeting can be used to	• Delineate the corridor • Provide privacy • Ensure against environmental harm from contaminated water
Containment basins can be	• Constructed with salvage covers and fire hose or ladders • Wading pools or portable drafting tanks
Also needed at the site	• Containers for stowing contaminated tools and PPE • Recovery drums or other types of containers • Plastic bags

10–137

Use indicators to mark decon corridors.

10–138

Law enforcement and military personnel leaving hot zone must undergo decontamination.

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

Local policies must establish procedures for decontaminating weapons, ammunition, and other equipment that could be damaged by exposure to liquid

10–139

A separate decon corridor may be established for armed emergency services personnel leaving the hot zone.

When law enforcement personnel go through decon, weapons are placed in a hazmat recovery bin supervised by a law enforcement officer wearing the correct level of PPE

10–140

Service dogs leaving the hot zone will need to undergo decontamination.

Courtesy of FEMA News Photos; photo by Jocelyn Augustino

Fire department personnel may have to assist in decontamination of animals

10–141

Criminal suspects must be supervised by law enforcement during the decontamination process.

If conducting technical decon, the suspect 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 departmental procedures for decontaminating criminal suspects

10–142

NOTE

At hazmat/WMD incidents, there may be requests to decontaminate animals and pets. Contingency plans should include guidelines for decontamination of animals and pets.

10–143

Cold water decon is challenging in freezing weather.

- Run-off water can quickly turn to ice
- If warm water not available, susceptible individuals can suffer cold shock or hypothermia
- Give consideration to protecting victims from exposure to cold temperatures, which can cause hypothermia

10–144

Consider how to best protect victims.

- Are wet methods necessary, or can disrobing and dry methods accomplish effective decon?
- Is wind chill a factor?
- Is shelter available for victims during and after decon?
- Is it possible to conduct decon indoors using sprinkler systems, indoor swimming pools, and locker room showers?
- If decon will be conducted indoors how will victims be transported?
- If decon must be conducted outside in freezing temperatures, how will icy conditions be managed?

10–145

WARNING

Individuals who have been exposed to chemical agents should undergo emergency decon immediately, regardless of ambient temperatures.

10–146

Know procedures for decontaminating evidence.

Evidence collected on the scene by law enforcement personnel

- Must be appropriately packaged
- Must be in approved bags or other evidence containers
- Will be decontaminated only on exterior of packaging
- Must document chain of custody

10–147

The effectiveness of decontamination operations should be evaluated.

- Evaluating effectiveness of decon may be done visually or with monitoring and detection devices or other equipment
- Check individuals after decon
- If victims still complaining of symptoms or effects recheck for contaminants
- If effectiveness of decon is called into question, victims should go through decon again

10–148

Tools and equipment must also undergo decontamination.

Tools and equipment Will normally need to be stored in the decon area until the emergency phase of the operation is completed

↓

After decon, will need to be checked to ensure all contamination has been removed before being placed back in service

↓

Apparatus will also need to undergo decon if exposed or potentially exposed to hazardous materials

↓

Decon of equipment, tools, and apparatus may be evaluated by the same monitoring and detection equipment used to determine effectiveness of decon on victims and responders

10–149

Effectiveness of decon should be verified with appropriate monitoring and detection equipment.

Courtesy of New South Wales Fire Brigades

10–150

REVIEW QUESTION

What factors influence the implementation of decontamination?

10–151

Learning Objective 10

Explain decontamination termination activities.

10–152

Multiple steps are involved in termination of decontamination activities.

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

10–153

Additional reports and supporting technical documentation may be required.

- Incident reports
- After action reports
- Regulatory citations
- Exposure records

10–154

Exposure records are required for all first responders exposed or potentially exposed to hazardous materials.

- Follow SOP/Gs for filling out exposure records
- Follow-up examinations should be scheduled with medical personnel if necessary
- Copies of exposure records should be kept by the individual and by their personal physician and employer

10–155

An incident activity log must be created and maintained.

Log should include information captured during the incident debrief

- Must document chronology of events and activities that occurred during incident and decon
- SOPs should spell out additional requirements for local recordkeeping and reports

REVIEW QUESTION

What post incident paperwork is unique to hazmat incidents?

Chapter 10: Implementing the Response: Decontamination Answers

Key Terms

1. **Technical Decontamination** – Using chemical or physical methods to thoroughly remove contaminants from responders (primarily entry team personnel) and their equipment; usually conducted within a formal decontamination line or corridor following gross decontamination. *Also known as* Formal Decontamination.
2. **Ambulatory –** People, often responders who are able to understand directions, talk, and walk unassisted.
3. **Mass Decontamination** – Process of decontaminating large numbers of people in the fastest possible time to reduce surface contamination to a safe level. It is typically a gross decon process utilizing water or soap and water solutions to reduce the level of contamination, with or without a formal decontamination corridor or line.
4. **Mass Casualty Incident** – Incident that results in a large number of casualties within a short time frame, as a result of an attack, natural disaster, aircraft crash, or other cause that is beyond the capabilities of local logistical support.
5. **Triage** – System used for sorting and classifying accident casualties to determine the priority for medical treatment and transportation.

True/False

1. False
2. True
3. False
4. True
5. False
6. True
7. True
8. False
9. False
10. True
11. True

Fill in the Blank

1. hazardous materials, terrorism
2. contaminants
3. external, internal
4. exposure
5. responders, victims, PPE, tools, equipment
6. gross, emergency, technical, mass
7. gross decontamination
8. psychological, anxiety, shortness of breath
9. number of persons, type of hazardous material, weather, personnel and equipment available
10. terrorist, evidence
11. get it off, keep it off, contain it
12. technical

13. chemical
14. ambulatory
15. time constraints
16. monitoring
17. existing facilities
18. emergency response personnel
19. gender, families
20 deceased
21. decon
22. bagged, tagged
23. law enforcement officer
24. exposure
25. activity log

Picture Identification

Types of decontamination operations.

1. Runoff water from decon is often contained in pools or other catch basins
2. They are using dry decon; using sorbent powders or similar materials
3. Quickly; emergency decon aims to remove contamination as quickly as possible
4. Chemical or physical methods
5. Technical decon by brushing and scraping; no, brushing and scraping is used before other types of decon
6. Evaporation; gaseous materials such as ammonia or others with high vapor pressure
7. He is contaminated with hazardous material; isolation and disposal
8. Washing involves soap or other surfactants mixed with water; dilution involves water
9. Nonambulatory
10. Large volume of low pressure water
11. Individual bags and ID tags, disposable garments, towels, shoes
12. A system of rollers
13. Rubber; leather gloves can absorb contaminants
14. There is a line for females and another for males
15. Dogs must undergo decon before leaving the hot zone

Matching

Part I: Technical Decontamination Techniques

1. B
2. L
3. D
4. J
5. H
6. K
7. I
8. E
9. F
10. G
11. A
12. C

Multiple Choice

1. D
2. D
3. C
4. B
5. B
6. A

Short Answer

1. *Answers may vary; students should include at least two of the following.*
   Do not create large amounts of contaminated liquid runoff
   May be accomplished through the systematic removal of disposable PPE while avoiding contact with contaminants
   May be used during cold weather operations when wet methods are difficult to implement
2.
   Chemical degradation
   Sanitization
   Disinfection
   Sterilization
   Neutralization
   Solidification
3. Because of increased awareness of firefighters' cancer risk
4.
   Fast to implement
   Requires minimal equipment
   Reduces contamination quickly
   Does not require a formal contamination reduction corridor or decon process
5. All contaminants are not removed, so a more thorough decon must follow; emergency decon can harm the environment.
6. *Answers may vary; students should include at least five of the following.*
   "First Aid" section of the safety data sheet(s) (SDS)
   Emergency response centers (such as CHEMTREC, CANUTEC, SETIQ)
   Container information labels
   Pre-incident plans
   Technical experts
   ERG
   Poison control centers
   Other books, references sources, computer programs, and/or data bases
7. When the number of victims and time constraints do not allow establishment of an in-depth decontamination process such as technical decon
8. *Answers may vary; students should include some of the following.*
   Communicate with victims using hand signals, signs with pictures, apparatus public address systems, megaphones or other methods to direct them to decon gathering areas as well as through the decon process itself
   Provide simple and specific directions that can be easily understood, since people may be traumatized and/or suffering from exposures

Use barrier tape, traffic cones, or other highly visible means to mark decon corridors

9.

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

10. *Answers may vary; students should include at least three of the following.*

Hand signals
Signs with pictures
Public address systems
Megaphones

11. *Answers may vary; students should include at least six of the following.*

Wind direction
Weather
Accessibility
Time
Terrain and surface material
Lighting (and electrical supply)
Drains and waterways
Water supply

12. In the warm zone on the dirty side of the decon line

13.

Evidence must be appropriately packaged
Chain of custody must be documented when evidence passes through decon

14.

Incident reports
After action reports
Regulatory citations
Exposure records

15.

The individual
The individual's personal physician
The individual's employer

16. OSHA standard 29 *CFR* 1910.1020 Access to Employee Exposure and Medical Records

Hazardous Materials for First Responders Fifth Edition

Chapter 13 — Implementing the Response: Mission-Specific Product Control

HAZARDOUS MATERIALS FOR FIRST RESPONDERS
FIFTH EDITION

IFSTA

Learning Objective 1

Describe methods of spill control.

13–1

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

Attempts to

- Reduce the amount of contact made with
  - People
  - Property
  - Environment
- Limit the amount of potential harm caused by products

13–2

Control actions involving spills are generally defensive.

Courtesy of Rich Mahaney

13–3

NOTE

Responders should familiarize themselves with their AHJ's policies and procedures for product control as specified in SOPs and emergency response plans.

13–4

Spill control is used to confine a hazardous material after a release.

- Spill control is often simply called confinement
- Some spill-control tactics minimize amount of harm that contact with the material causes
- Spill control primarily acts as a defensive operation
- Responders' safety is a primary consideration

13–5

Responders should use spill control to confine hazardous material after release.

Spills may involve

Gases	Liquids	Solids

Product involved may be released into

Into air	Into water	Onto a surface

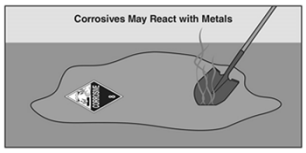
Type of release determines spill control method needed to control it

Multiple methods are used to control the spread of liquid materials.

Methods include

- Building dams or dikes near the source
- Catching the material in another container
- Directing (diverting) the flow to a remote location for collection

If the spill involves a corrosive material, it may react with metals or damage other materials .



Large or rapidly spreading spills may require the use of specialized equipment.

Before using equipment to confine spilled materials ICs need to

- Seek advice from technical sources
- Determine if spilled materials will adversely affect equipment

Equipment may include

- Heavy construction-type equipment
- Floating confinement booms
- Special sewer and storm drain plugs

Courtesy of U.S. EPA

Spill control is not restricted to controlling liquids.

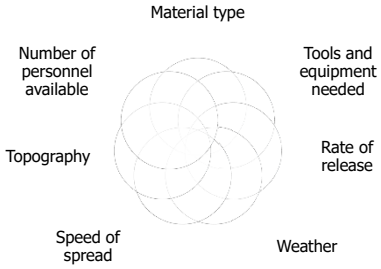
Responders may also need to control

- Dusts
- Vapors
- Gases

With

- Protective covering consisting of a fine spray of water
- A layer of earth
- Plastic sheets
- Salvage covers
- Foam blankets on liquids
- Strategically placed water streams

Multiple factors dictate confinement efforts.



CAUTION

Undertake spill-control actions ONLY if you can perform tasks without coming into direct contact with the hazardous material.

Operations level responders take protective actions.

Some defensive spill-control tactics attempt to reduce the amount of harm that the material causes.

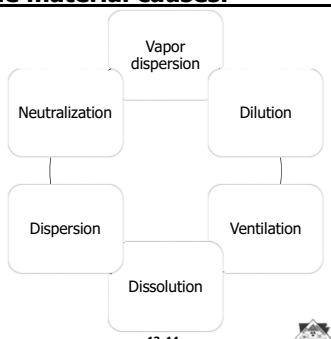


Table 13.1 provides potential spill control tactics for different types of releases and dispersions.

Absorption soaks up or retains a liquid hazardous material in some other material.

Bulk of liquid being absorbed enters cell structure of absorbing medium

Absorbent must be chemically compatible with material being absorbed

Absorbents tend to swell as they absorb

Multiple types of absorbents may be used at hazmat incidents.

Common absorbents used at hazmat incidents include	Sawdust
	Clays
	Charcoal
	Polyolefin-type fibers
	Specially designed absorbent pads, pillows, booms, and socks

Absorbent is spread directly onto the hazardous material or in location where material is expected to flow.

After use, responders must treat and dispose of absorbents as hazardous materials because they retain the properties of the materials they absorb

13–18

Absorption is often used at incidents involving small spills.

Responders often use absorption at incidents involving small spills (55 gallons or less) (208 L), such as gasoline or diesel fuel

- Some absorbents, such as sawdust, may work best on shallow pools
- Responders may use absorbent booms for releases involving waterborne spills in streams or pools

13–19

In adsorption the molecules of the liquid hazardous material physically adhere to the adsorbent material.

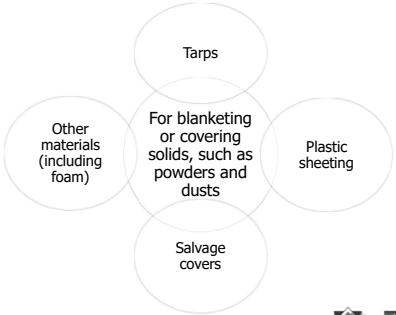
- The hazardous materials does not enter into the cell spaces
- Adsorbents tend not to swell like absorbents do
- Responders usually use organic-based materials as adsorbents
- Adsorbents primarily used to control shallow liquid spills
- Adsorbent MUST be compatible with spill material

13–20

Personnel perform blanketing or covering to prevent dispersion of hazardous materials .

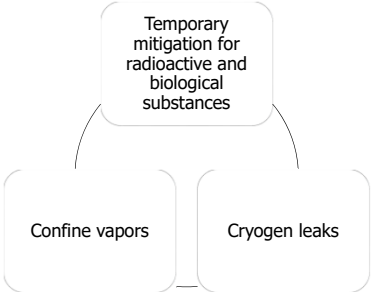
13–21

Consider the compatibility between materials being covered and material covering it.



13–22

Blanketing/covering may be used on multiple types of hazmat incidents.



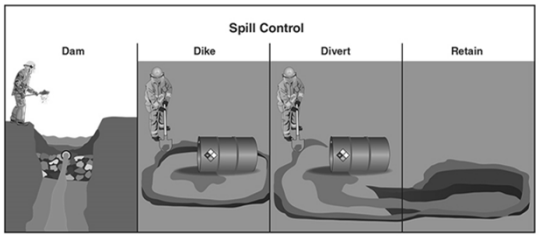
13–23

Covering an anhydrous ammonia release causes it to auto-refrigerate beneath the tarp.

Courtesy of Rich Mahaney

13–24

Damming, diking, diverting, and retaining are common methods to control liquid spills.



13–25

Dam, dike, diversion, or use retain a liquid hazardous material to control its flow.

Responders can use available earthen materials or materials carried on their response vehicles to construct curbs that direct or divert flow away from

- Gutters
- Drains
- Storm sewers
- Flood-control channels
- Outfalls

13–26

It may be desirable to direct flow into certain locations in order to capture and retain material.

13–27

A dam may permit water to pass over (or under) the dam, while holding back the hazardous material.

13–28

Vapor suppression reduces the emission of vapors at a hazmat incident.

Examples of foam suppression include

- Using fire fighting foam to suppress vapors from flammable and combustible liquids
- Using water fog from hose streams or
- Chemical vapor suppressants

13–29

Foam is sometimes used to suppress flammable liquid vapors.

13–30

Vapor dispersion directs or influences the course of airborne hazardous materials.

- Pressurized streams of water from hoselines or unattended master streams may help disperse vapors
- Creates turbulence, which increases rate of materials mixing with air
- Reduces concentration of hazardous material
- Responders must confine and analyze runoff water for possible contamination

13–31

Pressurized water streams from hoselines or unattended master streams can be used for vapor dispersion.

13–32

Ventilation is performed to control air movement.

When spills occur inside structures, ventilation can remove and/or disperse harmful

- Airborne particles
- Vapors
- Gases

13–33

Personnel can apply the same ventilation techniques used for smoke removal to hazmat incidents.

- Ensure compatibility of ventilation equipment with hazardous atmosphere
- During negative-pressure ventilation, ensure fans and other ventilators are compatible with atmosphere where they are being operated
- Ensure that equipment is intrinsically safe in a flammable atmosphere
- Remember that positive-pressure ventilation removes atmospheric contaminants more effectively than negative-pressure ventilation

13–34

Dispersion involves breaking up a spilled hazardous material.

Dispersion may pose problems

Often has unfortunate effect of spreading material over wide area	Process itself may cause additional problems

Because of these problems, use of dispersants may require approval of government authorities

13–35

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

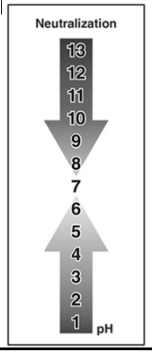
- Diluting hazardous water-soluble liquids requires huge volumes of water that may create runoff problems
- Responders may use dilution at spills involving small amounts of corrosive material
- Generally considered for use only after spill control methods have been rejected

13–36

Responders use dilution frequently during decontamination operations.

13–37

Neutralization is used to shift the pH of closer to 7 (neutral).



- Neutralization is a difficult process
- Adding too much of a neutralizer can cause a pH shift in the opposite direction
- Reactions can also release tremendous heat

13–38

REVIEW QUESTIONS

What is the difference between absorption and adsorption?

Under what circumstances might blanketing or covering be used?

13–39

REVIEW QUESTIONS

What types of materials are used in damming, diking, diversion, and retention?

What are three common methods of vapor suppression?

13–40

REVIEW QUESTIONS

Explain the difference between negative- and positive-pressure ventilation.

What problems are posed by dispersion?

13–41

REVIEW QUESTIONS

When is dilution at hazmat incidents most likely to be used?

When neutralizing a material, what pH is the goal?

13–42

Learning Objective 2

Describe methods of leak control.

13–43

Leak-control tactics are used to contain the product in its original (or another) container, preventing it from escaping.

A leak involves physical breach in a container through which product escapes

Leak control often referred to as containment

Tactics and tasks determined by

- Type of container involved
- Type of breach
- Properties of the material

13–44

Operations level responders can perform leak control only under certain circumstances.

In situations involving

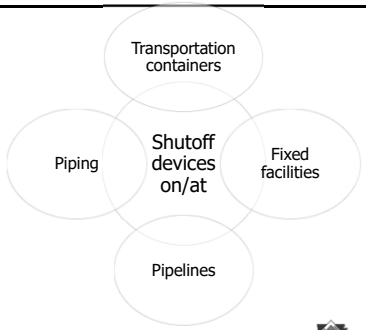
- Gasoline
- Diesel
- Liquefied petroleum gas (LPG)
- Natural gas fuels

Operations responders can take offensive actions provided they have appropriate

- Training
- Procedures
- Equipment
- PPE

13–45

Operations level responder may also operate shutoff devices.



13–46

Transportation container emergency shutoff devices may sometimes be operated by Operations responders.

Under safe and acceptable circumstances, Operations responders may operate emergency remote shutoff devices on

- Cargo tank trucks
- Intermodal containers

13–47

Cargo tank truck shutoff devices locations vary.

13–48

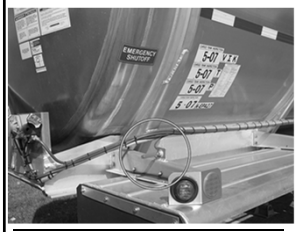
High pressure tanks (MC-331) will typically have shutoff devices behind the driver's side cab and on the right rear.

Courtesy of Rich Mahaney

13–49

Know the locations for shutoff devices on nonpressure liquid tanks and low-pressure chemical tanks.

Courtesy of Rich Mahaney



An emergency shutoff device on the left-front corner of the tank (behind the driver)

Some will also have one on either the right or the left rear corner

Some cargo tanks may have emergency shutoffs in the center of the tank near valves and piping, or built into the valve box

13–50

Know where to find the emergency shutoff devices for intermodal containers.

Gas service (high pressure and cryogenic) intermodal containers will have emergency shutoffs for the bottom internal valve

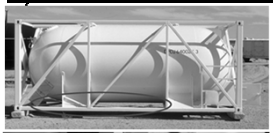
Other containers may have them, depending on manufacturer or owner

Look for metal cable running down one side of the frame rail of intermodal container or from liquid valve to a fixed point away from container

Pull cable to activate emergency shutoff	May also be able to pull handle or other device to activate emergency shutoff device

13–51

On high pressure and cryogenic intermodal containers, look for a metal cable running down the rail for shutoff.



Courtesy of Rich Mahaney

13–52

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

These remote shutoff or control valves can be operated to stop flow of product to an incident area without entering hot zone

Depending on the diameter and length of piping, a significant amount of product may release for some time before the flow stops

13–53

Responders should NOT shut any valves without direction from facility or pipeline operators .

Courtesy of the Texas Commission on Fire Protection

Closing valves without knowledgeable input may cause potentially dangerous consequences

13–54

First responders may shut off valves to residential natural gas lines.

The shutoff is an inline valve located on owner supply side of meter; that is, between distribution system and meter

When valve is open, the tang is in line with pipe

To close valve, use a spanner wrench, pipe wrench, or similar tool to turn the tang until it is 90 degrees to pipe

Contact local utility company when gas has been shut off or when any emergency involving natural gas occurs in its service area

13–55

REVIEW QUESTION

Under what circumstances may Operations level responders take offensive actions such as leak control?

13–56

REVIEW QUESTIONS

Under safe circumstances, Operations level responders may operate emergency remote shutoff devices on what types of transportation containers?

When should responders operate fixed facility or pipeline remote shutoff valves?

13–57

Learning Objective 3

Describe methods of fire control at a hazmat incident.

13–58

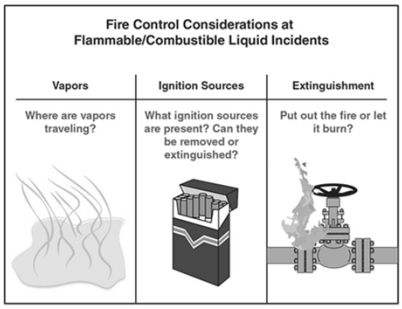
Fire control attempts can be used to minimize the damage, harm, and effect of fire at a hazmat incident.

Courtesy of Rich Mahaney

Fire-control tactics are used to extinguish fires and prevent ignition of hazardous materials

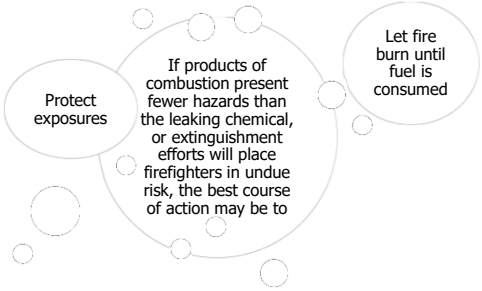
13–59

Consider the factors at hazardous flammable or combustible liquids incidents.



13–60

Extinguishment is not always the best tactic.



13–61

Consider multiple options, including withdrawal.

Responders should consider withdrawal as potentially the safest (and best) tactical option due to

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

13–62

NOTE

The *2016 Emergency Response Guidebook* provides BLEVE safety precautions on pp. 368-369.

13–63

WARNING

Do not assume that relief valves are sufficient to safely relieve excess pressures. Tanks with relief valves may still rupture violently if exposed to heat or flames.

13–64

Most hazmat incidents involve flammable and combustible liquids.

Incidents range from

Spilled fuel at car accidents to	Major industrial accidents involving bulk containers

Spill control methods used will depend on the incident

13–65

Turnout gear can absorb flammable/ combustible liquids, which can later ignite if exposed to an ignition source.

13–66

Most hazmat incidents involve flammable and combustible liquids.

At flammable and combustible liquid incidents, always consider	Firefighter protective clothing can absorb flammable and combustible liquids, which can later ignite if exposed to an ignition source
	Avoid contact with products and/or contaminated pools, puddles, or streams
	Vapors from flammable and combustible liquids are usually heavier than air
	Flammable and combustible liquids are typically lighter than water and, if so, will float on the surface of water
	Flammable and combustible liquids are Class B materials; water is an ineffective extinguishing agent
	Flammable and combustible liquid vapors may be toxic

13–67

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

Vapor suppression using fire fighting foam can be effective if the foam concentrate is compatible with the hazardous material

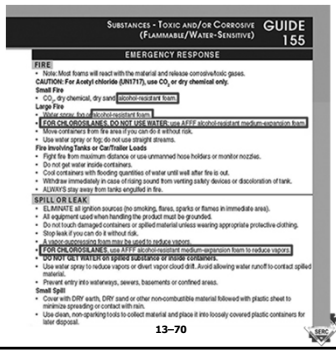
Class B foam concentrates are used on flammable and combustible liquids

13–68

Do NOT use regular fluoroprotein and regular aqueous film forming foam on flammable/combustible liquids.

13–69

The *ERG* provides guidance on when to use alcohol-resistant foam for a particular material.



SUBSTANCES - TOXIC AND/OR CORROSIVE (FLAMMABLE/WATER-SENSITIVE) GUIDE 155

EMERGENCY RESPONSE

FIRE

- Note: Most foams will react with the material and release corrosive/toxic gases.

CAUTION: For Acetyl chloride (UN1717), use CO_2 or dry chemical only.

Small Fire

- CO_2, dry chemical, dry sand, alcohol-resistant foam.

Large Fire

- Water spray, fog or alcohol-resistant foam.
- FOR CHLOROSILANES, DO NOT USE WATER: use AFFF alcohol-resistant medium-expansion foam.
- Move containers from fire area if you can do it without risk.
- Use water spray or fog; do not use straight streams.

Fire Involving Tanks or Car/Trailer Loads

- Fight fire from maximum distance or use unmanned hose holders or monitor nozzles.
- Do not get water inside containers.
- Cool containers with flooding quantities of water until well after fire is out.
- Withdraw immediately in case of rising sound from venting safety devices or discoloration of tank.
- ALWAYS stay away from tanks engulfed in fire.

SPILL OR LEAK

- ELIMINATE all ignition sources (no smoking, flares, sparks or flames in immediate area).
- All equipment used when handling the product must be grounded.
- Do not touch damaged containers or spilled material unless wearing appropriate protective clothing.
- Stop leak if you can do it without risk.
- A vapor-suppressing foam may be used to reduce vapors.
- FOR CHLOROSILANES: use AFFF alcohol-resistant medium-expansion foam to reduce vapors.
- DO NOT GET WATER on spilled substance or inside containers.
- Use water spray to reduce vapors or divert vapor cloud drift. Avoid allowing water runoff to contact spilled material.
- Prevent entry into waterways, sewers, basements or confined areas.

Small Spill

- Cover with DRY earth, DRY sand or other non-combustible material followed with plastic sheet to minimize spreading or contact with rain.
- Use clean, non-sparking tools to collect material and place it into loosely covered plastic containers for later disposal.

13–70

WARNING

When performing vapor-suppression tactics, stay upwind from the product and vapors because they may ignite.

13–71

Table 13.2 reviews foam types and applications of foam that may be used during hazmat responses.

Table 13.2
Foam Concentrate Characteristics/Application Techniques

Type	Characteristics	Application Techniques	Primary Uses
Protein Foam (3% and 6%)	• Protein based • Low expansion • Good reignition (burnback) resistance • Excellent water retention • High heat resistance and stability • Performance can be affected by freezing and thawing • Can freeze protect with antifreeze • Not as mobile or fluid on fuel surface as other low-expansion foams	• Indirect foam stream; do not mix fuel with foam • Avoid agitating fuel during application; static spark ignition of volatile hydrocarbons can result from plunging and turbulence • Use alcohol-resistant type within seconds of proportioning • Not compatible with dry chemical extinguishing agents	• Class B fires involving hydrocarbons • Protecting flammable and combustible liquids where they are stored, transported, and processed
Fluoroprotein Foam (3% and 6%)	• Protein and synthetic based; derived from protein foam • Fuel shedding • Long-term vapor suppression • Good water retention • Excellent, long-lasting heat resistance • Performance not affected by freezing and thawing • Maintains low viscosity at low temperatures • Can freeze protect with antifreeze • Use either freshwater or saltwater • Nontoxic and biodegradable after dilution • Good mobility and fluidity on fuel surface • Premixable for short periods of time	• Direct plunge technique • Subsurface injection • Compatible with simultaneous application of dry chemical extinguishing agents • Deliver through air-aspirating equipment	• Hydrocarbon vapor suppression • Subsurface application to hydrocarbon fuel storage tanks • Extinguishing in-depth crude petroleum or other hydrocarbon fuel fires
Film Forming Fluoroprotein Foam (FFFP) (3% and 6%)	• Protein based; fortified with additional surfactants that reduce the burnback characteristics of other protein-based foams • Fuel shedding • Develops a fast-healing, continuous-floating film on hydrocarbon fuel surfaces • Excellent, long-lasting heat resistance • Good low-temperature viscosity • Fast fire knockdown • Affected by freezing and thawing • Use either freshwater or saltwater • Can store premixed • Can freeze protect with antifreeze • Use alcohol-resistant type on polar solvents at 6% solution and on hydrocarbon fuels at 3% solution • Nontoxic and biodegradable after dilution	• Cover entire fuel surface • May apply with dry chemical agents • May apply with spray nozzles • Subsurface injection • Can plunge into fuel during application	• Suppressing vapors in unignited spills of hazardous liquids • Extinguishing fires in hydrocarbon fuels

Continued

Table 13.2 (concluded)
Foam Concentrate Characteristics/Application Techniques

Type	Characteristics	Application Techniques	Primary Uses
Aqueous Film Forming Foam (AFFF) (1%, 3%, and 6%)	• Synthetic based • Good penetrating capabilities • Spreads vapor-sealing film over and floats on hydrocarbon fuels • Can use nonaerating nozzles • Performance may be adversely affected by freezing and storing • Has good low-temperature viscosity • Can freeze protect with antifreeze • Use either freshwater or saltwater • Can premix	• May apply directly onto fuel surface • May apply indirectly by bouncing it off a wall and allowing it to float onto fuel surface • Subsurface injection • May apply with dry chemical agents	• Controlling and extinguishing Class B fires • Handling land or sea crash rescues involving spills • Extinguishing most transportation-related fires • Wetting and penetrating Class A fuels • Securing unignited hydrocarbon spills
Alcohol-Resistant AFFF (3% and 6%)	• Polymer has been added to AFFF concentrate • Multipurpose: Use on both polar solvents and hydrocarbon fuels (use on polar solvents at 6% solution and on hydrocarbon fuels at 3% solution) • Forms a membrane on polar solvent fuels that prevents destruction of the foam blanket • Forms same aqueous film on hydrocarbon fuels as AFFF • Fast flame knockdown • Good burnback resistance on both fuels • Not easily premixed	• Apply directly but gently onto fuel surface • May apply indirectly by bouncing it off a wall and allowing it to float onto fuel surface • Subsurface injection	Fires or spills of both hydrocarbon and polar solvent fuels
High-Expansion Foam	• Synthetic detergent based • Special purpose, low water content • High air-to-solution ratios: 200:1 to 1,000:1 • Performance not affected by freezing and thawing • Poor heat resistance • Prolonged contact with galvanized or raw steel may attack these surfaces	• Gentle application; do not mix foam with fuel • Cover entire fuel surface • Usually fills entire space in confined space incidents	• Extinguishing Class A and some Class B fires • Flooding confined spaces • Volumetrically displacing vapor, heat, and smoke • Reducing vaporization from liquefied natural gas spills • Extinguishing pesticide fires • Suppressing fuming acid vapors • Suppressing vapors in coal mines and other subterranean spaces and concealed spaces in basements • Extinguishing agent in fixed extinguishing systems • Not recommended for outdoor use

Table 13.2
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Continued

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Alcohol-Resistant AFFF (3% and 6%)	• Polymer has been added to AFFF concentrate • Multipurpose: Use on both polar solvents and hydrocarbon fuels (use on polar solvents at 6% solution and on hydrocarbon fuels at 3% solution) • Forms a membrane on polar solvent fuels that prevents destruction of the foam blanket • Forms same aqueous film on hydrocarbon fuels as AFFF • Fast flame knockdown • Good burnback resistance on both fuels • Not easily premixed	• Apply directly but gently onto fuel surface • May apply indirectly by bouncing it off a wall and allowing it to float onto fuel surface • Subsurface injection	Fires or spills of both hydrocarbon and polar solvent fuels
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Foam concentrates vary in their effectiveness.

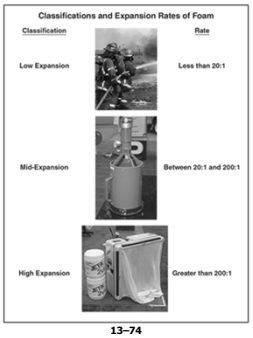
Foam quality is measured in terms of its 25-percent-drainage time and its expansion ratio

- Drainage time is the time required for one-fourth (25 percent or one-quarter) 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

In general, the required application rate to control an unignited liquid spill is substantially less than that required to extinguish a spill fire

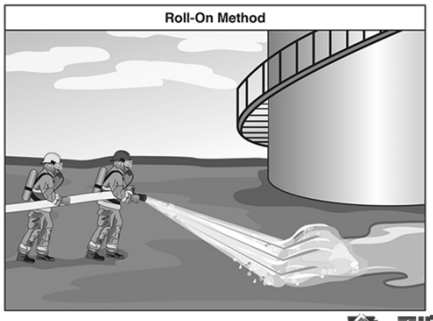
13–73

Remember: the greater the foam expansion ratio is, the thicker the foam blanket that can be developed.



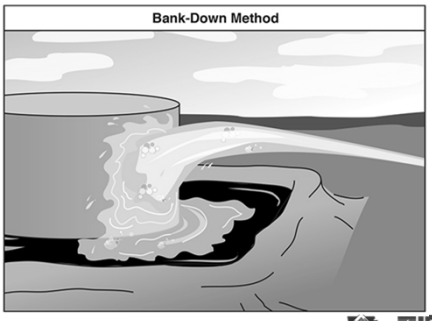
13–74

The roll-on application method involves applying the foam onto the ground at the edge of the spill.



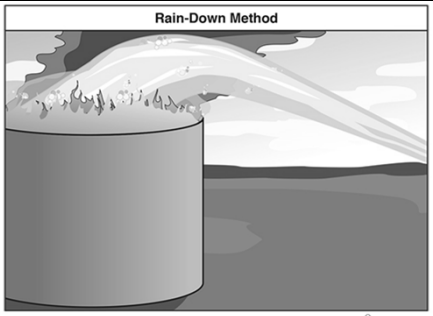
13–75

If the spill surrounds some type of obstacle, responders can use the bank-down application method.



13–76

Personnel using the rain-down method spray the foam into the air over the target area in a fog pattern.



13–77

For vapor suppression, first responders should use air-aspirating nozzles rather than water fog nozzles.

13–78

Adequate vapor suppression relies on selection of the proper foam concentrate.

- Do not use water streams in conjunction with the application of foam
- Ensure that a material is below its boiling point; foam cannot seal vapors of boiling liquids
- Do not rely on the film that precedes the foam blanket
- Reapply aerated foam periodically until the foam completely covers the spill

13–79

CAUTION

Do not use the following agents in conjunction with foam: ABC (monoammonium phosphate) dry chemical and some sodium bicarbonate-based BC dry chemical agents will destroy a foam blanket. Other agents, such as potassium-based dry chemical, are compatible with foam.

13–80

CAUTION

Before use, check foam compatibility.

13–81

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

If personnel applies extinguishing agents incorrectly	May push fuel to unwanted locations, endangering people or exposures
If personnel applies the wrong agent	May place firefighters or personnel in hazardous locations without possibility of controlling fire

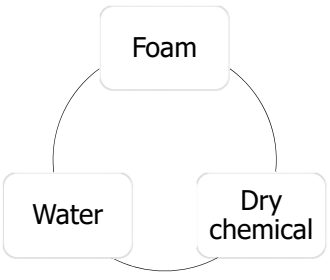
13–82

WARNING

If initial water streams are inadequate to cool both the pressurized tank and exposures, give priority to the involved container. Failure to maintain the integrity of the tank will risk the lives of everyone present.

13–83

Know the common extinguishing agents for flammable liquids.



13–84

Foam must be compatible with the fuel that is burning and it must be applied at a sufficient rate to extinguish the fire.

13–85

WARNING

PPE soiled with flammable and combustible liquids may ignite when exposed to heat or an ignition source. Properly decontaminate and inspect the PPE.

13–86

Remember to plan for unburned vapors.

Unburned vapors

- Are usually heavier than air
- Form pools or pockets of gas in low areas where they may ignite

13–87

An increase in the intensity of sound or fire from a pressure relief device may indicate container stress.

Emergency responders should not assume that pressure relief devices will safely relieve excess pressures under severe fire conditions

Rupture of both large and small liquid containers has caused firefighter fatalities

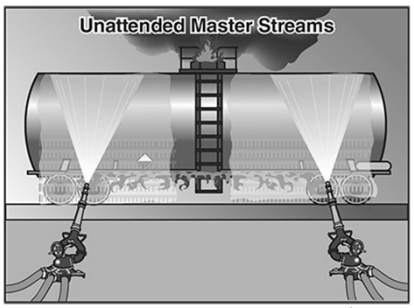
13–88

If a closed pressure container, such as a liquefied gas (LPG) tank, is heated, BLEVE is a possibility.

1. Liquid inside begins expanding
2. When liquid reaches boiling point, it begins to return to its gaseous state
3. Internal pressure on vessel increases
4. If too much pressure builds up, container loses its structural integrity and ruptures
5. Massive amounts of pressure and flammable contents of the container are released

13–89

Apply water to upper portions of tank, preferably from unattended master stream devices.



13–90

Flammable gas fires in tanks pose a BLEVE risk.

To prevent BLEVE	Deploy water streams for maximum effective reach when containers exposed to flame impingement	
	Direct stream(s)	At area on tank where there is direct flame impingement
		Along tank's top so that water runs down both sides
		Cool piping and steel support under tanks to prevent collapse

13–91

Cool flammable gas tanks with water running down both sides of the tank.

13–92

Deliver water streams so that it disperses or disrupts escaping gas.

13–93

Do not extinguish gas-fed fires burning around relief valves or piping.

Unless turning off supply can stop the leaking product

An increase in intensity of sounds or fire issuing from a relief valve indicates

Pressure within the container is increasing	Container failure may be imminent

13–94

Some gas-fed fires may involve natural gas.

Natural gas

- May be compressed, stored, and shipped in cylinders marked as compressed natural gas (CNG)
- Also shipped and stored as a liquid (LNG) and is subject to BLEVE in this form
- Excavation equipment breaking through underground pipes is a common cause of natural gas (CNG) and liquefied petroleum gas (LPG) incidents

13–95

Contact the utility company immediately if a natural gas incident occurs.

- Even if gas has not yet ignited, apparatus should approach from and stage on upwind side, on side from which the wind is blowing
- Must wear full PPE and prepare for a potential explosion and accompanying fire
- First evacuate area immediately around the break and area downwind
- Eliminate ignition sources

13–96

Service connections near the break may have been damaged; check the inside of surrounding buildings for a gas odor.

Firefighters should follow their departmental SOPs regarding any kind of interaction with a gas line leak
If gas is burning, the flame should not be extinguished
If necessary, use hose streams to protect exposures
Responders should contact the utility company and make an attempt to have pressurized gas supply stopped

13–97

WARNING

DO NOT extinguish a fire if gas is burning from a broken gas pipe, valve, fitting, or flange. DO provide protection for exposures, and contact the utility company immediately.

13–98

REVIEW QUESTIONS

When should withdrawal be considered as a tactical option during a hazmat fire?

What tactics are used for flammable and combustible liquid spill control?

13–99

REVIEW QUESTIONS

What tactics are used for flammable and combustible liquid fire control?

What tactics are used to control flammable gas fires?

13–100

Chapter 13: Implementing the Response: Mission-Specific Product Control Answers

Section A: Key Terms

1. **Control** – To contain, confine, neutralize, or extinguish a hazardous material or its vapor.
2. **Confinement** – The process of controlling the flow of a spill and capturing it at some specified location.
3. **Neutralization** – Chemical reaction resulting from an acid and a base reacting with each other.
4. **Dam** – Actions to prevent or limit the flow of a liquid or sludge past a certain area.
5. **Dike –** Actions using raised embankments or other barriers to prevent movement of liquids or sludges to another area.
6. **Divert** – Actions to direct and control movement of a liquid or sludge to an area that will produce less harm.
7. **Retain** – Actions to contain a liquid or sludge in an area where it can be absorbed, neutralized, or removed. Often used as a longer-term solution than other similar product control methods.
8. **Vapor Suppression** – Action taken to reduce the emission of vapors at a hazardous materials spill.
9. **Vapor Dispersion** – Action taken to direct or influence the course of airborne hazardous materials.
10. **Ventilation** – Systematic removal of heated air, smoke, gases or other airborne contaminants from a structure and replacing them with cooler and/or fresher air to reduce damage and facilitate fire fighting operations.
11. **Intrinsically Safe –** Describes equipment that is approved for use in flammable atmospheres; must be incapable of releasing enough electrical energy to ignite the flammable atmosphere.
12. **Dilution** – Application of water to a water-soluble material to reduce the hazard.
13. **Containment** – The act of stopping the further release of a material from its container.
14. **Extinguish** – To put out a fire completely.
15. **Class B Foam Concentrate** – Foam fire-suppression agent designed for use on ignited or unignited Class B flammable or combustible liquids. *Also known as* Class B Foam.
16. **Aqueous Film Forming Foam (AFFF)** – Synthetic foam concentrate that, when combined with water, can form a complete vapor barrier over fuel spills and fires and is a highly effective extinguishing and blanketing agent on hydrocarbon fuels.
17. **Drainage Time** – Amount of time it takes foam to break down or dissolve. *Also known as* Drainage, Drainage Dropout Rate, or Drainage Rate.
18. **Expansion Ratio** – 1) Volume of a substance in liquid form compared to the volume of the same number of molecules of that substance in gaseous form. 2) Ratio of the finished foam volume to the volume of the original foam solution. *Also known as* Expansion.
19. **Roll-On Application Method** – Method of foam application in which the foam stream is directed at the ground at the front edge of the unignited or ignited liquid fuel spill; foam then spreads across the surface of the liquid. *Also known as* Bounce.
20. **Bank-Down Application Method** – Method of foam application that may be employed on an ignited or unignited Class B fuel spill. The foam stream is directed at a vertical surface or object that is next to or within the spill area; foam deflects off the surface or object and flows down onto the surface of the spill to form a foam blanket. *Also known as* Deflection.
21. **Rain-Down Application Method** – Foam application method that directs the stream into the air above the unignited or ignited spill or fire, allowing the foam to float gently down onto the surface of the fuel.
22. **Air-Aspirating Foam Nozzle** – Foam nozzle designed to provide the aeration required to make the highest quality foam possible; most effective appliance for the generation of low-expansion foam.

True/False

1. True
2. True
3. False
4. False

5. False
6. False
7. True
8. False
9. False
10. True
11. True
12. True

Fill in the Blank

1. contain, container
2. enter, hot zone
3. natural gas lines

Picture Identification

WB 13.3
WB 13.4

Matching

1. F
2. B
3. I
4. C
5. E
6. J
7. G
8. A
9. H
10. D

Short Answer

1. *Answers may vary; students should include the following:*

Spill-control tactics confine a hazardous material that has been released from its container. Leak- control tactics are used to contain the product in its original (or another) container, preventing it from escaping.

2. *Answers may vary; students should include five of the following:*

Absorption
Adsorption
Blanketing/Covering
Dam, Dike, Diversion, Retention
Vapor Suppression
Vapor Dispersion
Ventilation
Dispersion
Dilution
Neutralization

3. *Answers may vary; students should include some of the following:*
   Cargo tank trucks
   Intermodal containers
   Fixed facilities
   Pipelines
4.
   Threat of catastrophic container failure
   Boiling liquid expanding vapor explosion (BLEVE) or other explosion
   Resources needed to control incident are unavailable.
5.
   Roll-on
   Bank-down
   Rain-down