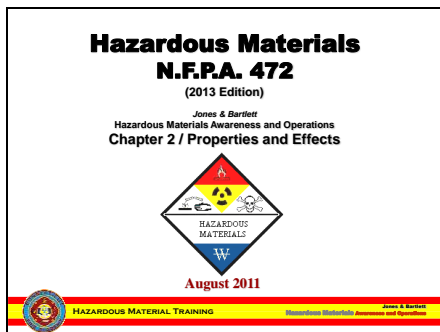


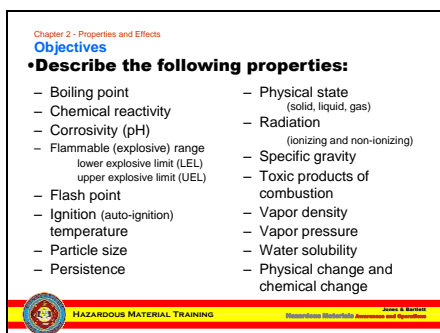


Slide 1

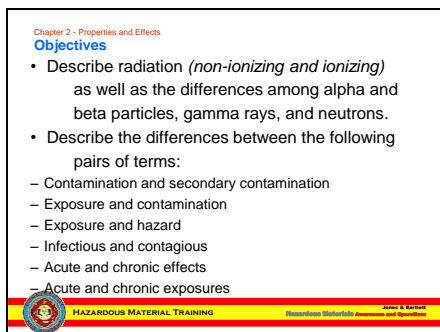


To understand hazardous materials incidents, it is important to know the chemical and physical properties of the substances involved. Chemical and physical properties are the characteristics of a substance that are measurable, such as vapor density, flammability, and water reactivity. When responding to hazardous materials/WMD incidents, responders must fully understand the hazards to minimize the potential for exposure. This includes knowing the routes of entry into the body and avoiding contamination. Caution and the use of proper equipment can offer protection and help ward off acute and chronic health effects.

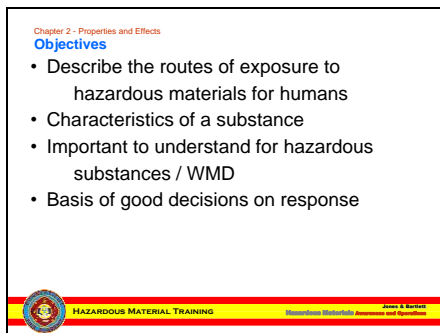
Slide 2



Slide 3



Slide 4





Slide 5

Introduction

- Chemical and Physical Properties
 - Characteristics of a substance
 - Important to understand for hazardous substances/WMD
 - Basis of good decisions on response
 - Are measurable
 - They include:
 - Vapor density
 - Flammability
 - Corrosivity
 - Water Reactivity

HAZARDOUS MATERIAL TRAINING

Physical and Chemical Properties

Physical properties are those that can be observed without changing the identity of the substance.

The general properties of matter such as color, density, hardness, are examples of physical properties.

Properties that describe how a substance changes into a completely different substance are called chemical properties.

Flammability and corrosion/oxidation resistance are examples of chemical properties.

Slide 6

Physical and Chemical Changes

State of Matter

The state of matter identifies the hazard as a solid, liquid, or gas.

HAZARDOUS MATERIAL TRAINING

Phases of Matter Each phase of matter has its own chemical and physical properties. The phases of matter you need to know are:

Solid - a solid has a definite shape and volume

Liquid - a liquid has a definite volume, but can change shape

Gas - the shape and volume of a gas can change

Phase Changes

These phases of matter can change from one to another.

Remember the definitions of the following phase changes:

Melting - melting occurs when a substance changes from a solid to a liquid

Boiling - boiling is when a substance changes from a liquid to a gas

Condensing - condensation is when a gas changes to a liquid

Freezing - freezing is when a liquid changes to a solid

Slide 7

Physical and Chemical Changes

State of Matter

- Helps predict what substance will do
 - How will it escape its container?
 - Why did the container fail?
- Influences the incident's duration
 - In turn, informs emergency response plan

HAZARDOUS MATERIAL TRAINING

It is not necessary to be a chemist to respond safely to hazardous materials incidents.

In most cases, you can be guided by

Careful observation

Referring to your emergency response plan and/or standard operating procedure


Correctly interpreting visual clues presented



Slide 8

Physical and Chemical Changes

- Can occur when chemicals are subjected to
 - Heat
 - Cold
 - Pressure



HAZARDOUS MATERIAL TRAINING

The difference between a physical and chemical property is straightforward until the phase of the material is considered.

When a material changes from a solid to a liquid to a vapor it seems like they become a different substance. However, when a material melts, solidifies, vaporizes, condenses or sublimates, only the state of the substance changes. Consider ice, liquid water, and water vapor, they are all simply H₂O.

Phase Changes

These phases of matter can change from one to another.

Remember the definitions of the following phase changes:

Melting - melting occurs when a substance changes from a solid to a liquid

Boiling - boiling is when a substance changes from a liquid to a gas

Condensing - condensation is when a gas changes to a liquid

Freezing - freezing is when a liquid changes to a solid

Physical Changes

Physical changes are concerned with energy and states of matter. A physical change does not produce a new substance. Changes in state or phase (melting, freezing, vaporization, condensation, sublimation) are physical changes. Examples of physical changes include crushing a can, melting an ice cube, and breaking a bottle.

Chemical Changes

Chemical changes take place on the molecular level. A chemical change produces a new substance. Examples of chemical changes include combustion (burning), cooking an egg, rusting of an iron pan, and mixing hydrochloric acid and sodium hydroxide to make salt and water.

How to Tell Chemical & Physical Changes Apart

A chemical change makes a substance that wasn't there before. There may be clues that a chemical reaction took place, such as light, heat, color change, gas production, odor, or sound. The starting and ending materials of a physical change are the same, even though they may look different.




Slide 9

Physical and Chemical Changes

BLEVE

- **B**oiling **L**iquid/**E**xpanding **V**apor **E**xplosion
 - Pressurized liquefied materials inside closed vessel are exposed to high heat
 - Results in physical change from liquid to gas
- Examples: propane, butane
- Expansion ratio: Describes the volume increase that occurs


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Hazardous Materials Assessment and Operations

BLEVE (Boiling Liquid/Expanding Vapor Explosion)
Caused by pressurized liquefied materials inside a closed vessel exposed to high heat
This causes the substance to change from liquid to gas.
Propane and butane are examples.

Slide 10

Physical and Chemical Changes

BLEVE



Fire impinging on a propane tank.


As heat increases inside of tank, the pressure also increases. The liquid air begins to boil.

As the pressure increases, the relief valve will open, releasing propane and pressure being heavier than air, will sink.

The vapor will reach the fire and ignite.

The relief valve will open, also causing heat to be on the tank for short time. The pressure will increase in the tank.

As the pressure in the tank is increasing, the tank may deform and the effect of the relief valve will get higher. Eventually the tank will rupture. This is known as a BLEVE.

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Expansion ratio is a description of the volume increase that occurs when a liquid changes to a gas.
Propane has an expansion ratio of 270 to 1.
For every 1 volume of liquid propane, 270 times that amount of propane exists as vapor.


Slide 11

Physical and Chemical Changes

BLEVE

- Fireball can engulf responders and exposures
- Metal debris can fly considerable distances
- Liquid propane can be released and ignite
- The shock wave, air blast, or flying metal created by the BLEVE can collapse buildings or move responders and equipment



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BLEVE (pronounced BLEV-ee), (Boiling Liquid/Expanding Vapor Explosion) occurs when a vessel containing a pressurized liquid above its boiling point ruptures.
If a vessel partly filled with liquid with vapor above filling the remainder of the container, is ruptured—for example, due to corrosion, or failure under pressure—the vapor portion may rapidly leak, lowering the pressure inside the container. This sudden drop in pressure inside the container causes violent boiling of the liquid, which rapidly liberates large amounts of vapor. The pressure of this vapor can be extremely high, causing a significant wave of overpressure (an explosion) which may completely destroy the storage vessel and project fragments over the surrounding area.

Propane and butane are examples





Slide 12

Physical and Chemical Changes

BLEVE

- Firefighters should withdraw immediately in the case of rising sound from a venting relief valve or discoloration of the tank
- Fire must be fought from a distance with unmanned monitors or hoses that are cooling the tank with a minimum of 500 GPM
- If water is vaporizing on contact, apply more water
- Avoid icing around the relief valves



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Hazardous Materials Awareness and Operations

Fires: BLEVEs can be caused by an external fire near the storage vessel causing heating of the contents and pressure build-up. While tanks are often designed to withstand great pressure, constant heating can cause the metal to weaken and eventually fail. If the tank is being heated in an area where there is no liquid, it may rupture faster without the liquid to absorb the heat. Gas containers are usually equipped with relief valves that vent off excess pressure, but the tank can still fail if the pressure is not released quickly enough.

If the substance involved is flammable, it is likely that the resulting cloud of the substance will ignite after the BLEVE has occurred, forming a fireball and possibly a fuel-air explosion, also termed a vapor cloud explosion (VCE). If the materials are toxic, a large area will be contaminated.


Incidents: In August 1959 the Kansas City Fire Department was hit with their largest loss of life in the line of duty deaths to date, when a 25,000 gallon gas tank exploded during a fire on Southwest Boulevard killing five firefighters. This was the first time BLEVE was used to describe a burning fuel tank. Significant industrial BLEVEs include accidents at Sunray, Texas in 1956, Glasgow, Scotland in 1960, Feyzin, France in 1966; Crescent City, Illinois in 1970; Kingman, Arizona in 1973; Texas City, Texas in 1978; Murdock, Illinois in 1983; and San Juan Ixhuatepec, Mexico City in 1984. In 1978, a BLEVE occurred after a traffic collision involving a LPG truck in the Los Alfaques disaster in Spain.


Slide 13

Physical and Chemical Changes

Chemical Reactivity

- Also known as chemical change
- Ability to transform at molecular level
- Usually releases some form of energy
- Examples
 - Steel when it rusts
 - Wood when it burns



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Chemical reactivity (also known as chemical change) describes the ability of a substance to undergo a transformation at the molecular level.

Usually with a release of some form of energy

Physical change is essentially a change in state. By contrast, a chemical change results in an alteration of the chemical nature of the material.


Examples are steel when it rusts and wood when it burns.



Slide 14

Critical Characteristics of Hazardous Materials

- **Flash Point**
- **Ignition Temperature**
- **Flammable Range**
- **Only substances in gaseous or vapor state will combust**
 - Solids and liquids produce vapor, then ignite




HAZARDOUS MATERIAL TRAINING



Slide 15

Critical Characteristics of Hazardous Materials

Flash Point



- Minimum temperature at which ignition results in flash fire
- Fire will go out once vapor fuel is consumed

HAZARDOUS MATERIAL TRAINING

Flash point

The flash point of a volatile liquid is the lowest temperature at which it can vaporize to form an ignitable mixture in air. Measuring a liquid's flash point requires an ignition source. At the flash point, the vapor may cease to burn when the source of ignition is removed.

The flash point is not to be confused with the autoignition temperature, which does not require an ignition source.

Ignition source examples:

- Flame
- Electrical equipment
- Lightning
- Static electricity

Common substances with low flash points, resulting in higher ignition temperatures and vapor pressures:

- Gasoline
- Ethyl alcohol
- Acetone


#2 grade diesel fuel has a high flash point, resulting in lower ignition temperature and lower vapor pressure.

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Critical Characteristics of Hazardous Materials

Flash Point

- **Low Flash Point** = higher ignition temperatures and vapor pressures
 - Examples: Gasoline, ethyl alcohol, acetone
- **High Flash Point** = lower ignition temperatures and vapor pressures
 - Example: #2 grade diesel fuel



Responders should always be mindful of ignition sources at flammable/combustible liquid incidents.



HAZARDOUS MATERIAL TRAINING

The flash point is often used as a descriptive characteristic of liquid fuel, and it is also used to help characterize the fire hazards of liquids. “Flash point” refers to both flammable liquids and combustible liquids. There are various standards for defining each term. Liquids with a flash point less than 141°F or 100°F — depending upon the standard being applied — are considered flammable, while liquids with a flash point above those temperatures are considered combustible.

Common substances with low flash points, resulting in higher ignition temperatures and vapor pressures:

- Gasoline
- Ethyl alcohol
- Acetone

#2 grade diesel fuel has a high flash point, resulting in lower ignition temperature and lower vapor pressure.




Slide 17

Critical Characteristics of Hazardous Materials

Fire Point

- Temperature at which sustained combustion of vapor occurs
- Usually slightly higher than flash point



HAZARDOUS MATERIAL TRAINING

The fire point of a fuel is the temperature at which it will continue to burn for at least 5 seconds after ignition by an open flame. At the flash point, a lower temperature, a substance will ignite briefly, but vapor might not be produced at a rate to sustain the fire.


Most tables of material properties will only list material flash points, but in general the fire points can be assumed to be about 10°C higher than the flash points.

Slide 18

Critical Characteristics of Hazardous Materials

Ignition Temperature

- Also known as Autoignition Temperature
- Temperature at which heated fuel ignites and continues to burn
- No external ignition source necessary



HAZARDOUS MATERIAL TRAINING

Ignition temperature

Also referred to as Autoignition temperature

The minimum temperature at which a fuel, when heated, will ignite in air and continue to burn

No external ignition source is necessary.

Example is a pan full of cooking oil on the stove, left unattended on a burner set on high

Once the oil is heated past 300°F (148°C)—its ignition temperature—it will ignite.


In fact, this is a common cause of stove fires.

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Critical Characteristics of Hazardous Materials

Flammable Range

- Concentrations (%) of flammable vapor and air needed for fuel/air mixture to burn
- Defined by lower and upper limits:
 - Lower explosive limit (LEL)
 - Upper explosive limit (UEL)
- More dangerous material has wider range



HAZARDOUS MATERIAL TRAINING

Flammable range

Expression of fuel/air mixture, defined by upper and lower limits, that reflects an amount of flammable vapor mixed with a given volume of air

Boundaries necessary to burn

Lower explosive limit (LEL)

Upper explosive limit (UEL)

For gasoline, the LEL is 1.4 percent and the UEL is 7.6 percent.

Generally, the wider the flammable range, the more dangerous the material



Slide 20

Critical Characteristics of Hazardous Materials

Vapor Pressure

- Pertains to liquids inside closed container
- May be expressed in:
 - Pounds per square inch (PSI)
 - Atmospheres (atm)
 - Torr
 - Millimeters of mercury (mm Hg)
- 14.7 psi = 1 atm = 760 torr = 760 mm Hg

HAZARDOUS MATERIAL TRAINING

Vapor pressure

Applies to liquids held inside any type of closed container
All liquids, including water, develop a certain amount of pressure in the airspace between the top of the liquid and the container.

The vapors released from the surface of any liquid must be contained if they are to exert pressure.

Expressed in

Pounds per square inch (psi)

Atmospheres (atm)

Torr

Millimeters of mercury (mm Hg)

14.7 psi = 1 atm = 760 torr = 760 mm Hg

Vapor pressure increases as ambient temperature increases.


Liquids with higher vapor pressures evaporate more quickly than those with lower vapor pressures.

Slide 21

Critical Characteristics of Hazardous Materials

Vapor Pressure

The vapors released from the surface of any liquid must be contained if they are to exert pressure.



- Influenced by ambient temperature
 - High temp. → increased vapor pressure
 - Low temp. → decreased vapor pressure
- Causes liquid to evaporate when released
 - High vapor pressure → evaporates quickly
 - Low vapor pressure → evaporates slowly

HAZARDOUS MATERIAL TRAINING

As a general trend, vapor pressures of liquids at ambient temperatures increase with decreasing boiling points.

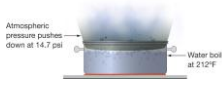
For example, at any given temperature, propane has a high vapor pressure. It also has the low boiling point (−42.1 °C) at 1 one atmosphere (atm).

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Critical Characteristics of Hazardous Materials

Boiling Point

- Liquid continually gives off vapors
- Molecules must overcome downward force of atmospheric pressure
- If maintained, all liquid will turn into gas



Atmospheric pressure pushes down at 14.7 psi

Water boils at 212°F

The concept of boiling point versus atmospheric pressure.

HAZARDOUS MATERIAL TRAINING

Boiling point

Temperature at which a liquid will continually give off vapors in sustained amounts
Open liquids must overcome the downward force of atmospheric pressure.

If held at that temperature long enough, will turn completely into a gas

Flammable liquids with low boiling points are dangerous because they have the potential to produce large volumes of flammable vapor at relatively low temperatures.

Liquids at their boiling point in closed containers are a hazard—vapor pressure will build up, eventually causing a container to fail.




Slide 23

Critical Characteristics of Hazardous Materials

Vapor Density

- Weight of vapor compared to weight of air
 - Expressed numerically (e.g., in the MSDS)
 - Air has set vapor density of 1.0
 - Vapor density > 1.0 = heavier; < 1.0 = lighter
- Affects gas' behavior during release
- Lighter-than-air gases: "4H MEDIC ANNA"



Vapor density < 1.0 over the cylinder with the gas leak rising upward.
Vapor density > 1.0 over the cylinder with the heavier-than-air leak.

HAZARDOUS MATERIAL TRAINING

Vapor density

Weight of an airborne concentration of a vapor or gas, compared to the weight of air

Expressed numerically (e.g., vapor density is given in the MSDS)

Air has a set vapor density of 1.0.

Gases with vapor density > 1.0 are heavier than air; gases with vapor density < 1.0 are lighter than air.

Affects where the gas goes when released.

In the field, in the absence of reliable reference sources, use this mnemonic to remember lighter-than-air gases: 4H MEDIC ANNA.

H: Hydrogen

H: Helium

H: Hydrogen cyanide

H: Hydrogen fluoride

M: Methane

E: Ethylene

D: Diborane

I: Illuminating gas (methane/ethane mixture)

C: Carbon monoxide

A: Ammonia

N: Neon

N: Nitrogen

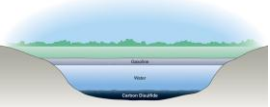
A: Acetylene

Slide 24

Critical Characteristics of Hazardous Materials

Specific Gravity

- Compares weight of liquid chemical to weight of water
- Water has specific gravity of 1.0
- Materials with specific gravity < 1.0 float
- Materials with specific gravity > 1.0 sink
- Most flammable liquids float on water



Gasoline will float on water, whereas carbon disulfide will not.

HAZARDOUS MATERIAL TRAINING

Specific gravity

Compares weight of liquid chemical to weight of water

Is to liquids what vapor pressure is to gases and vapors

Water has a specific gravity of 1.0.

Materials with a specific gravity less than 1.0 float.

Materials with a specific gravity greater than 1.0 sink.

Most flammable liquids float.


Examples are gasoline, diesel fuel, motor oil, and benzene.

Slide 25

Critical Characteristics of Hazardous Materials

Water Solubility

- Ability of substance to dissolve in water
- Water most often used to extinguish fires
 - Reacts violently with some chemicals (e.g., sulfuric acid, metallic sodium, magnesium)



HAZARDOUS MATERIAL TRAINING

Water solubility

The ability of a substance to dissolve in water

Water is the predominant agent used to extinguish fire.

But when dealing with chemical emergencies, it may not always be the best and safest choice.

Can react violently with certain chemicals, such as concentrated sulfuric acid, metallic sodium, and magnesium




Slide 26

Critical Characteristics of Hazardous Materials

Corrosivity

- Ability of a material to cause damage to
 - Skin, eyes, other body parts
 - Clothing, rescue equipment
- Corrosive chemicals should be taken seriously
 - Materials require unique response tactics



HAZARDOUS MATERIAL TRAINING

Corrosivity

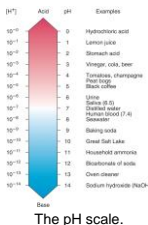
The ability of a material to cause damage (on contact) to skin, eyes, and other parts of the body. Also often damaging to clothing, rescue equipment, and other physical objects in the environment. Corrosives are a complex group of chemicals that should not be taken lightly. Tens of thousands of corrosive chemicals are used in general industry, semiconductor manufacturing, and biotechnology.

Slide 27

Critical Characteristics of Hazardous Materials

Corrosivity

- Two types:
 - Acids and Bases
- Defined by pH
 - Acids have pH greater than 7
 - Bases have pH less than 7
 - pH 7 is neutral
- pH < 2.5 or > 12.5 considered strong



The pH scale.

HAZARDOUS MATERIAL TRAINING

Two classes of corrosive chemicals: Acids and bases Measured by pH

Acids have pH greater than 7
Bases have pH less than 7
pH 7 is neutral
pH values of 2.5 or less and of 12.5 or more are considered strong.
Strong corrosives—acids or bases—will react more aggressively with metals, skin, other chemicals, and water.

Slide 28

Critical Characteristics of Hazardous Materials

Toxic Products of Combustion

- Materials decompose under heat, resulting in hazardous chemical compounds
- Smoke may not be just smoke!
 - Soot, carbon monoxide, carbon dioxide, water vapor, formaldehyde, cyanide compounds, nitrogen oxides

HAZARDOUS MATERIAL TRAINING

Toxic products of combustion

Hazardous chemical compounds released when a material decomposes under heat
Combustion is a chemical reaction, and like other reactions generates byproducts.
Smoke produced by a structure fire is familiar.
But what is in the smoke?
Toxic gases may be liberated during a residential structure fire.

Most fire smoke includes soot, carbon monoxide, carbon dioxide, water vapor, formaldehyde, cyanide compounds, and many oxides of nitrogen.
Most of these are toxic even in small doses.



Slide 29

Critical Characteristics of Hazardous Materials

Radiation

- Energy transmitted by electromagnetic waves or energetic particles
 - Sources: Sun, soil, X-rays, occupational exposures encountered in the field
- Amount absorbed and exposure time affect degree of damage

Alpha, beta, and gamma radiation.

HAZARDOUS MATERIAL TRAINING

Radiation

Energy transmitted through space in the form of electromagnetic waves or energetic particles

Radiation comes from many sources.

- Sun
- Soil
- X-rays

Occupational exposures encountered in the field

Health hazards posed determined by

- Amount of radiation absorbed by your body
- Exposure time to the radiation

Radioactivity is the process by which unstable atoms (isotopes) of an element decay to a different state and emit or radiate excess energy.

Typically, you will encounter a combination of alpha, beta, and gamma radiation.

Slide 30

Critical Characteristics of Hazardous Materials

Alpha Particles

- Have weight and mass
- Travel less than a few centimeters
- Protect yourself by:
 - Staying several feet from source
 - Using HEPA filter on simple respirator
 - Self-contained breathing apparatus (SCBA)

HAZARDOUS MATERIAL TRAINING

Alpha particles

Have weight and mass

As a consequence, cannot travel far—less than a few centimeters

You can protect yourself by staying several feet from the source and wearing a HEPA filter on a simple respirator or a self-contained breathing apparatus (SCBA).

Slide 31

Critical Characteristics of Hazardous Materials

Beta Particles

- More energetic than alpha particles
- Pose a greater health hazard
 - May redden (erythema) and burn skin
 - May be inhaled; use SCBA
- Can travel 10 to 15 feet in open air
- Are considered ionizing radiation
- Cannot pass through most solid objects

HAZARDOUS MATERIAL TRAINING

Beta particles

Beta particles are high-energy, high-speed electrons or positrons emitted by certain types of radioactive nuclei such as potassium-40. The beta particles emitted are a form of ionizing radiation also known as beta rays.

More energetic than alpha particles

Therefore pose a greater health hazard

May redden (erythema) and burn skin

May cause damage to tissue when inhaled

Can travel 10 to 15 feet in open air

Are considered ionizing radiation

Solid objects provide protection, and wearing an SCBA should provide respiratory protection.



Slide 32

Critical Characteristics of Hazardous Materials

Ionizing Radiation

- Can cause changes in human cells
- Can lead to cancer
- Examples: X-rays, gamma rays

HAZARDOUS MATERIAL TRAINING

Non-ionizing radiation is thought to be essentially harmless below the levels that cause heating. Ionizing radiation is dangerous in direct exposure,

Ionizing radiation

Can cause changes in human cells

Lower doses may cause cancer or other long-term problems

Examples include X-rays and gamma rays.

Slide 33

Critical Characteristics of Hazardous Materials

Non-Ionizing Radiation

- Comes from electromagnetic waves
- Does not have sufficient energy to change human cells
- Examples: Sound waves, radio waves, microwaves

HAZARDOUS MATERIAL TRAINING

Non-ionizing radiation

Non-ionizing radiation refers to any type of electromagnetic radiation that does not carry enough energy to ionize atoms or molecules—that is, to completely remove an electron from an atom or molecule.

Comes from electromagnetic waves

Non-ionizing radiation can produce non-mutagenic effects such as inciting thermal energy in biological tissue that can lead to burns.

Does not have sufficient energy to change human cells

Examples include: Near ultraviolet, visible light, infrared, microwave, radio waves, and low-frequency RF (long wave) are all examples of non-ionizing radiation.

Slide 34

Critical Characteristics of Hazardous Materials

Gamma Radiation

- Pure electromagnetic energy
- Most energetic radiation responders may encounter
- Passes easily through thick, solid objects
- Form of ionizing radiation; can be deadly
- SCBA will not provide protection
- Neutrons can create gamma radiation

HAZARDOUS MATERIAL TRAINING

Gamma radiation

Gamma radiation, also known as gamma-rays (especially in astronomy), is electromagnetic radiation of high frequency (very short wavelength). Gamma rays are produced by decay of high energy states in atomic nuclei (gamma decay) and also high energy sub-atomic particle interactions in natural processes and man-made mechanisms.

Pure electromagnetic energy

The most energetic radiation that responders may encounter

Has no mass, no electrical charge, and travels at the speed of light

Shielding from gamma rays requires large amounts of mass

Passes easily through thick solid objects

All ionizing radiation causes similar damage at a cellular level, but because rays of alpha particles and beta particles are relatively non-penetrating, external exposure to them causes only localized damage, e.g. radiation burns to the skin. Gamma rays and neutrons are more penetrating, causing diffuse damage throughout the body (e.g. radiation sickness), increasing incidence of cancer rather than burns.

SCBA will not provide protection.




Slide 35

Hazard, Exposure and Contamination of Hazardous Materials

Definitions

- Hazard: Material capable of causing harm
- Exposure: Process by which people, animals, the environment, and equipment come into contact with hazardous material

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A hazard is a material capable of posing an unreasonable risk to health, safety, or the environment—that is, capable of causing harm.


Exposure is the process by which people, animals, the environment, and equipment are subjected to or come into contact with a hazardous material.

Slide 36

Hazard, Exposure and Contamination of Hazardous Materials 2

Contamination

- Residue from released chemical
 - Decontamination: Process of residue removal
- Secondary contamination is transferred from source by direct contact
- PPE protects *if contact cannot be avoided*
 - Does not enable unlimited contact

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Contamination is the residue of a released chemical.

Decontamination is the process of removing the residue resulting from a chemical release.

Secondary contamination

Also known as cross-contamination

Occurs when a person or object transfers the contamination, or the source of contamination, to another person or object by direct contact

Responders often have the misperception that PPE is worn to enable them to contact the product at will.


In fact, PPE is worn to protect you in the event that you cannot avoid product contact.


Slide 37

Weapons of Mass Destruction

Weapons of Mass Destruction (WMD)

- Mnemonic for types of damage: TRACEMP
 - **T**hermal
 - **R**adiological
 - **A**sphyxiation
 - **C**hemical
 - **E**tiological (anthrax, plague, smallpox)
 - **M**echanical
 - **P**sychogenic




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Slide 38

Weapons of Mass Destruction

Nerve Agents

- Enter body through lungs or skin
- Disrupt central nervous system
- May cause death or serious impairment
 - Dose absorbed dictates extent of damage
- Examples: Sarin, VX



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Slide 39

Weapons of Mass Destruction
Nerve Agents

•Signs/symptoms: "**SLUDGEM**"

- S alivation	- G astric disturbance
- L acrimation (tearing)	- E mesis (vomiting)
- U rination	- M iosis (constriction of the pupil)
- D efecation	

HAZARDOUS MATERIAL TRAINING

SLUDGEM syndrome is a mnemonic of a syndrome (often a toxidrome) of pathological effects indicative of massive discharge of the parasympathetic nervous system. Unlikely to occur naturally, SLUDGEM is usually encountered only in cases of drug overdose, ingestion of certain poisonous mushrooms (particularly the muscarine-containing members of the genera *Inocybe* and *Clitocybe*), or exposure to nerve gases. Nerve gases irreversibly inhibit the enzyme acetylcholinesterase; this results in a chronically high level of acetylcholine at cholinergic synapses throughout the body, thus chronically stimulating acetylcholine receptors throughout the body. The symptoms of "SLUDGE" are due to chronic stimulation of muscarinic acetylcholine receptors, in organs and muscles innervated by the parasympathetic nervous system. It is useful to remember some of the symptoms of increased cholinergic stimulation through the mnemonic

SLUDGEM:

- Salivation: stimulation of the salivary glands
- Lacrimation: stimulation of the lacrimal glands
- Urination: relaxation of the internal sphincter muscle of urethra, and contraction of the detrusor muscles
- Defecation: relaxation of the internal anal sphincter
- Gastrointestinal upset: Smooth muscle tone changes causing gastrointestinal problems, including diarrhea
- Emesis: Vomiting
- Miosis: stimulation of the pupillary constrictor muscles or Muscle spasm: stimulation of skeletal muscle

- Nerve Gas or Sarin

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Weapons of Mass Destruction
Blister Agents

- Also known as vesicants
- Cause blistering of the skin
- Interact in harmful ways with body
- Examples: Sulfur mustard, Lewisite



Blister agent exposure.

HAZARDOUS MATERIAL TRAINING

Blister agents

Also known as vesicants

Have ability to cause blistering of the skin

Interact in harmful ways with the human body

Examples include sulfur mustard and Lewisite.



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Weapons of Mass Destruction

Blood Agents

- Disrupt oxygen transfer from blood to cells
- Can be inhaled
- Can be ingested or absorbed through skin
- Example: Cyanide compounds
 - Typical signs/symptoms: Vomiting, dizziness, watery eyes, deep and rapid breathing

HAZARDOUS MATERIAL TRAINING

Blood agents

Chemicals that, when absorbed the body, interfere with transfer of oxygen from the blood to the cells

Can be inhaled or ingested or absorbed through the skin

Cyanide compounds are examples.

Typical signs/symptoms of exposure to cyanide compounds:

Vomiting, dizziness, watery eyes, as well as deep and rapid breathing

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Weapons of Mass Destruction

Choking Agents

- Inhibit breathing and are skin irritants
- Extremely irritating odor
- Intended to incapacitate, but may kill
 - May cause pulmonary edema (“dry drowning”)
- Examples: Chlorine, phosgene, chloropicrin

HAZARDOUS MATERIAL TRAINING

Choking agents

Inhibit breathing

Have an extremely irritating odor

Are intended to incapacitate, but may in fact kill or cause serious injuries (e.g., pulmonary edema or “dry drowning”)

Examples include chlorine, phosgene, and chloropicrin.

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Weapons of Mass Destruction

Irritants (Riot Control Agents)

- Cause pain and burning sensation
 - Exposed to skin, eyes, mucous membranes
 - Used to briefly incapacitate a person or group
- Least toxic of the WMD groups
 - Decontaminate with water; effects are meant to wear off
- Example: Mace

HAZARDOUS MATERIAL TRAINING

Irritants (riot control agents)

Cause pain and a burning sensation when exposed to skin, eyes, and mucous membranes

Used to temporarily incapacitate a person or a group of people

From a terrorism perspective, may be employed to incapacitate rescuers or to drive a group of people into another area where a more dangerous substance can be released

Least toxic of the WMD groups

Decontamination can be performed with clean water.

Effects are meant to wear off

An example is mace.




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Weapons of Mass Destruction

Convulsants

- Cause convulsions or seizures
- Even small exposure can be fatal
- Examples: Sarin, soman, tabun, VX
 - Also organophosphate and carbamate pesticides

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Convulsants

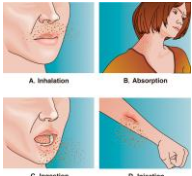
Cause convulsions or seizures when absorbed by the body
Can be fatal even in small doses
Examples include sarin, soman, tabun, VX, as well as organophosphate and carbamate pesticides.


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Harmful Substances

Harmful Substances' Routes of Entry Into Body

- Inhalation:
 - Through lungs
- Absorption:
 - Through skin
- Ingestion:
 - Through gastrointestinal tract
- Injection:
 - Through cuts or breaches in skin



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Routes of entry are inhalation, absorption, ingestion, and injection.


- Inhalation: Through the lungs
- Absorption: By permeating the skin
- Ingestion: Via the gastrointestinal tract
- Injection: Through cuts or other breaches in the skin

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Harmful Substances' Routes of Entry Into Body


Inhalation

- **Hazardous Materials/WMD**
 - Corrosive Materials, Particles
- SCBA offers excellent protection
- Infectious and contagious organisms also hazard
- Example: Anthrax



Air-purifying respirators protect against certain airborne chemical hazards

- More comfortable
- Allow longer work periods

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Inhalation

Exposures occur when harmful substances are brought into the body through the respiratory system.

Hazardous Materials / WMD

- Corrosive materials, such as chlorine and ammonia
- Solvent vapors, such as gasoline and acetone
- Superheated air
- Small particles of dust and smoke
- Infectious and contagious organisms, such as anthrax

SCBA offers excellent protection.

Full-face and half-face air purifying respirators (APRs) can offer protection, depending on the hazard.
More comfortable
Allow for longer work periods, because they do not rely on a limited supply of air




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Harmful Substances' Routes of Entry Into Body

Absorption

- Through skin, eyes, nose, mouth
- Asphyxiants may form, causing suffocation
- Some agents are carcinogens
- Aggressive solvents (e.g., paint stripper and hydrofluoric acid)

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Absorption

Process by which substances travel through body tissues until they reach the bloodstream
Occurs through skin, eyes, nose, mouth, and, to a certain extent, through the intestinal tract
The body, in attempting to metabolize the substance after it is absorbed, may produce an asphyxiant as a byproduct.
Asphyxiants prevent the body (at the cellular level) from using oxygen, thereby causing suffocation.
Some agents are carcinogens.
Aggressive solvents, such as paint stripper and hydrofluoric acid, are readily absorbed.

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Harmful Substances' Routes of Entry Into Body

Ingestion

- Chemicals enter body through GI tract
- May occur when rotating out from emergency
- After hazardous work, wash before drinking/eating

Injection

- Via cuts, abrasions, open wounds
- Address these before reporting for duty

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Ingestion

Chemicals are brought into the body through the gastrointestinal tract.
May inadvertently occur when rotating out from an emergency response for rest and refreshment, when not taking the time to wash up prior to eating or drinking

Injection

Chemicals enter the body through open cuts and abrasions. Address any cuts or open wounds before reporting for duty. If significant, you may be excluded from operating in contaminated environments.

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Health Effects

Chronic Health Hazards

- Appear after long-term exposure to hazard
- Also after multiple short-term exposures
- Target organ effect
 - Example: Asbestosis

Acute Health Hazards

- Occur after short, acute exposure
 - Examples: Acid burns (sulfuric acid), breathing difficulties, and skin irritation (formaldehyde, a "sensitizer")

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Chronic health hazards

Appear after long-term, or chronic, exposure to a hazardous substance
Also appear after multiple short-term exposures
Have a target organ effect
Chronic asbestosis exposures target the lungs.

Acute health effects


Occur after relatively short-term, or acute, exposure
Acid burns from sulfuric acid, as well as breathing difficulties and skin irritation resulting from exposure to formaldehyde (a "sensitizer") are two examples.



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Health Effects
Toxicity

- Degree to which something is toxic or poisonous
- Or, one such substance's adverse effects
- Lethal dose (LD)
- Lethal concentration (LC)
- OSHA descriptions based on LD and LC

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Toxicology is the study of adverse effects of chemical or physical agents on living organisms.


Toxicity

A measure of the degree that something is toxic or poisonous
 Also describes one such substance's adverse effects
 Lethal dose (LD) is a single dose that causes death by any route other than inhalation.
 Lethal concentration (LC) is the concentration in air that causes death.
 OSHA descriptions are based on the LD and LC.

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Properties & Effects
Summary


- Know chemical and physical properties of substances
- Important to making informed response
- Understand physical and chemical changes
- Be familiar with characteristics of flammable liquids
- Understand hazards before responding, to minimize potential for exposure
- Avoid contamination whenever possible

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Properties & Effects
Summary

- Hazardous substances/WMD enter the body through inhalation, ingestion, injection, and absorption
- May be used as WMD: Nerve agent, blister agent, blood agent, choking agent, irritant, convulsant
- HEPA filters and SCBA protect lungs
- Chronic health effects occur after years of exposure—wear protective gear!

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Slide 53

NEVER FORGET



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