

COURSE NUMBER 55-0505-9

5/18/2005

3 HOURS

PROPERTIES OF HAZ-MAT

Properties of Hazardous Materials



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&

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Lesson Title

Properties of Hazardous Materials

Lesson Objectives

1. Identify the seven ways that a first responder may be exposed to a hazardous material and how each effects the human body.
2. Identify the other hazards associated with a hazardous materials incident.
3. Identify the general routes of entry for human exposure to hazardous materials.

Time Frame

3 hours

Level of Instruction

Lecture

Materials Needed

Lesson plan
A.C.C. Fire and Emergency Services S.O.P.'s/S.O.G.'s
2004 Emergency Response Guidebook

References

I.F.S.T.A. Awareness Level Training for Hazardous Materials 1st Edition
Chapter 2

Course Goals

Prepare first responders to identify the harmful effects associated with exposure to hazardous materials and how these exposures may occur.

Introduction

This course looks at many of the various properties that make materials hazardous to humans. Included is information on how people may be exposed to various substances and how those exposed to hazardous materials are affected. The first responder will know how a hazardous material may enter the body and the importance of wearing special personal protective equipment to prevent such an exposure.

Health and Safety

- Primary consideration when dealing with Hazardous Materials
- An exposure to a hazardous material may be *acute* (single occurrence) or *chronic* (long-term, reoccurring) and may have health effects that are immediate or delayed.
- The following are harmful effects associated with hazardous materials:
 - Thermal
 - Mechanical
 - Poisonous
 - Corrosive
 - Asphyxiation
 - Radiation
 - Etiological

Thermal Effects

- Are related to temperature extremes.
- Affect the way an individual works and the amount of work an individual is capable of performing.
- **Heat Exposure**
 - **Heat Rash**
 - Result of continuous exposure to heat and humid air.
 - Can be aggravated by clothing rubbing the skin.
 - Reduces the individuals tolerance to heat
 - Can become annoying.
 - **Heat Cramps**
 - Occur after heavy exertion and exposure to high temperatures.
 - Develop in the body's extremities as a result of dehydration and excessive loss of salt.
 - The symptoms include the following:
 - Muscle cramps
 - Heavy Perspiration
 - Physical weakness
 - Moist skin
 - **Heat Exhaustion**
 - Results from prolonged physical work in a hot environment
 - The body is not capable of releasing excessive heat, causing a mild form of traumatic shock.
 - The symptoms include the following:
 - Mildly elevated temperature
 - Weak pulse
 - Dizziness
 - Profuse sweating
 - Cool, moist, pale skin

- **Heatstroke**
 - Results from not taking preventive measures when the body passes the heat exhaustion stage.
 - This is a serious medical emergency and if action is not taken it can become a life threatening situation.
 - The symptoms include the following:
 - Lack of perspiration
 - Shallow breathing
 - Rapid pulse
 - Headache
 - Weakness
 - Body temperature of 105°F or higher
 - Hot, dry, red skin
 - Confusion
 - Convulsion
 - Loss of consciousness
- **Ways to prevent and/or reduce the effects of heat exposure**
 - Plenty of fluids should be available. Water or commercial body-fluid-replenishment drink mixes may be used to prevent dehydration. The first responder should be encouraged to drink generous amounts of fluids both before and during operations even if they are not thirsty. Drinking 7 ounces of fluid every 15 to 20 minutes is better than drinking large quantities once an hour. Carbonated beverages should be avoided.
 - Responders should be given long cotton undergarments or similar types of clothing to provide natural body ventilation.
 - Mobile showers and misting facilities should be provided.
 - Rest areas, such as shaded and air-conditioned areas, should be provided.
 - Personnel should be rotated frequently.
 - Avoid or reduce intake of alcohol, coffee and caffeine before working, as they can contribute to dehydration and heat stress.
 - Personnel should be encouraged to maintain their physical fitness.
- **Cold Exposure**
 - A concern when dealing with cryogenic and liquefied gases.
 - **Cryogens**
 - A gas that turns into a liquid at or below -130°F.
 - Sometimes called refrigerated liquids.
 - Commonly stored and transported in their liquid state.

- Examples:
 - Liquid oxygen (LOX)
 - Nitrogen
 - Helium
 - Hydrogen
 - Liquid natural gas (LNG)
- Some have hazardous properties in addition to the cold hazard, such as fluorine, which is also a corrosive, an oxidizer and a poison.
- Have the ability to instantly freeze materials, including human tissue, on contact.
- **Liquefied Gases**
 - A gas that at the charging pressure is partially liquid at 70°F
 - Examples:
 - Propane
 - Carbon dioxide
- Both vaporize rapidly when released from their containers.
- A liquid spill or leak will boil into a much larger vapor cloud. These vapor clouds can be extremely dangerous if the vapors are flammable.
- Both cause freeze burns, which are treated as cold injuries according to their severity.

Condition and Symptoms of Cold Exposure

<u>Condition</u>	<u>Symptoms</u>
-Frost Nip/Incipient Frostbite	-Whitening or blanching of skin
-Superficial Frostbite	-Waxy or white skin -Firm touch to outer layers of skin -Underneath tissue is resilient (flexible)
-Deep Frostbite	-Cold skin -Pale skin -Solid, hard skin
-Systemic Hypothermia	-Shivering -Sleepiness, apathy, listlessness -Core temperature of 95°F or less -Slow pulse -Slow breathing -Glassy eyes -Unconsciousness -Freezing of extremities -Death

Mechanical Effects

- Mechanical trauma refers to damage that occurs as a result of direct contact with an object.
- The two most common types are striking and friction exposures.
 - **Striking Injuries**
 - Most likely due to the failure of a pressurized container.
 - Catastrophic failure of the container can result in bruises, punctures or even avulsions when the person is struck by the container or pieces of the container.
 - **Friction Injuries**
 - Less common in haz-mat operations, but when they do occur it's most commonly caused by contact between protective clothing and skin.
 - Occur as a result of portions of the body rubbing against an abrasive or otherwise irritating surface, causing raw skin, blisters and brush burns.

Poisonous Effects

- Exposure can cause damage to organs or other parts of the body and may even cause death.
- Types of poison and how they affect the body:
 - **Halogenated Hydrocarbons (Nephrotoxic Agents)**, affect the kidneys.
 - **Hematotoxic Agents**, such as benzene, nitrites, naphthalene and arsine, affect the blood.
 - **Organophosphate Pesticides**, such as parathion, are **Neurotoxin Agents** that affect the central nervous system.
 - **Hepatotoxic Agents**, such as ammonia, carbon tetrachloride and phenols, are examples of materials that affect the liver.
- The method by which poisons attack the body varies depending on the type of poison.
 - Irritants and asphyxiants interfere with the oxygen flow to the lungs and the blood.
 - Nerve poisons act on the body's central nervous system by disrupting the brain control center by blocking the nerve impulses that control the circulatory and respiratory systems.

Corrosive Effects

- Chemical exposures that destroy or burn living tissues and have destructive effects on other materials are called corrosives.
- Corrosives in contact with combustibles can result in a fire or an explosion.

- Corrosives are divided into two groups:
 - **Acids**
 - Hydrochloric acid, nitric acid and sulfuric acid are all common acids.
 - Acids may cause severe chemical burns to flesh and permanent eye damage. Typically there will be pain associated with an acid on contact.
 - **Bases**
 - Bases break down fatty skin tissues and can penetrate deeply into the body.
 - Caustic soda, potassium hydroxide and other alkaline materials are bases.
 - A sign of exposure to a base is a greasy or slick feeling of the skin, which is caused by the breakdown of the fatty tissues. Contact with a base does not normally cause immediate pain.
 - General Symptoms of external corrosive exposures include the following:
 - Burning around the eyes, nose and mouth
 - Nausea and vomiting
 - Difficulty breathing, swallowing or coughing
 - Localized burning or skin irritation.
 - Any hint of exposure should alert the first responder to withdraw to safety and assess the cause.
 - Any sudden deterioration, melting or discoloration of equipment should cause the first responder to have serious safety concerns.

Asphyxiation Effects

- Asphyxiants affect the oxygenation of the body and generally lead to suffocation.
- Can be divided into two classes: simple and chemical
 - **Simple Asphyxiants**
 - Inert gases that dilute the oxygen concentration below the level required by the human body.
 - May also displace the oxygen that is normally present - just as a gas that is heavier than air will fill a basement.
 - Examples:
 - Acetylene
 - Carbon dioxide
 - Helium
 - Hydrogen
 - Nitrogen
 - Methane
 - Ethane

- **Chemical Asphyxiants**
 - Substances that prohibit the body from using oxygen, also called blood poisons.
 - There are three ways that this can occur:
 - Compounds such as Carbon Monoxide (CO) react more readily with the blood than does oxygen. In this reaction, hemoglobin bonds to the CO instead of the oxygen, forming carbon dioxide (CO₂). The CO₂ is then transported to the cells, which die of oxygen starvation.
 - Compounds such as Hydrazine liberate hemoglobin from the red blood cells, leaving a lack of transport for the oxygen.
 - Compounds such as Benzene and Toluene cause a malfunction in the oxygen-carrying ability of red blood cells.
 - Other examples are:
 - Hydrogen cyanide
 - Aniline
 - Acetonitrile
 - Hydrogen sulfide

Radiation Effects

- Can cause somatic effects (injury to individuals) and genetic effects (changes to future generations).
- Can have internal and external effects on the human body.
 - Internal radiation effects occur when radioactive materials enter the body through respiration, ingestion or skin penetration.
 - External radiation effects come from radioactive sources outside the body.
- The severity of the injury will depend on the type of radiation, the dose rate, the body part exposed and the total dose received.
- Radiation effects include radiation sickness, radiation injury or radiation poisoning.
 - **Radiation Sickness**
 - Caused by exposure to large amounts of radiation.
 - Initial symptoms include nausea, vomiting and malaise.
 - **Radiation Injury**
 - Occur from high amounts of the less-penetrating types of radiation like beta particles.
 - Most commonly in the form of burns.
 - Usually confined to the hands, because such large amounts of exposure generally occur during improper handling of radiation sources.

- **Radiation Poisoning**
 - Caused by dangerous amounts of internal radiation.
 - Internal radiation can cause medical problems such as anemia or cancer.
 - Internal exposure from alpha particles is the most common cause of radiation poisoning.
- Radiation sickness, injury and poisoning are **NOT** contagious or infectious.
 - First responders may be exposed to the same source as the victim, but the victim will not cause harm because the victim cannot become radioactive.
 - If the victim is covered with a radioactive material, such as dust, first responders may become contaminated if they come into contact with the material.
- The potential for radiation exposure exists when first responders respond to facilities such as medical centers, industrial operations, power plants and research facilities.
- There are five basic types of radiation:
 - Alpha
 - Beta
 - X-Ray
 - Gamma
 - Neutron
- **Alpha Radiation**
 - Consists of particles having large mass and a positive electrical charge.
 - This radiation form is least dangerous as a threat to external portions of the body but is very dangerous when ingested, inhaled or otherwise allowed to enter the body.
 - Alpha particles may initially attach themselves to bone structure. However, in time they disintegrate and settle into organs such as the liver, kidneys, spleen and lungs.
 - Easily guarded against. An external alpha particle can be effectively blocked with a sheet of paper. Structural PPE and SCBA will prevent injury.
- **Beta Radiation**
 - Particles are very small. They are about 1/7000 the size of alpha particles but have more penetrating power.
 - Particles have a negative electrical charge.
 - Large quantities can seriously damage skin tissue.
 - Beta particles enter the body through damaged skin, ingestion or inhalation and cause organ damage similar to that of alpha.
 - Shielding from beta particles can be achieved by using heavy plastic, wood or thin metal. Structural PPE and SCBA are required to protect against beta particles hazards.

- **X-Ray and Gamma Radiation**
 - Both are electromagnetic forms of radiation bearing no particular electrical charge.
 - The two are very similar, differing mainly in their origin.
 - X-ray radiation rays arise from a complete atom.
 - Gamma rays arise solely from the nucleus of the atom.
 - Both rays move at the speed of light (186,000 miles/second).
 - When controlled, these types of radiation have useful purposes such as medical applications. Controlled gamma radiation is used for x-rays and many other purposes.
 - When uncontrolled, these two are the most dangerous forms of penetrating radiation. They may cause somatic and genetic effects to those exposed to them.
 - Materials that are very dense, such as lead, effectively shield against gamma and x-ray radiation. Structural PPE provides **NO** protection against the penetrating power of gamma rays.
- **Neutrons**
 - This type has a physical mass like alpha radiation but has no electrical charge.
 - Highly penetrating
 - Uncontrolled radioactive reactions produce neutrons along with gamma radiation.
 - Neutron radiation is difficult to measure in the field and is usually estimated based on gamma measurements.
 - Not commonly used in commercial or industrial operations, usually encountered in research laboratories.
 - The health hazard that neutrons present arises from the fact that they cause the release of secondary radiation.
- **Three ways to provide protection from external radiation during an emergency:**
 - **Time**---The shorter the exposure time, the smaller the total radiation dose.
 - **Distance**---The farther the distance from the source, the smaller the dose. Doubling the distance from the radioactive source gives one-fourth the exposure.
 - **Shielding**---Certain materials, such as lead, earth, concrete and water, will prevent penetration of some of the radioactive particles. The thickness of the shielding should depend on the type of material, the type of radiation and the distance from the source. Wearing PPE, including SCBA, will generally protect emergency response personnel from internal radiation caused ingestion, inhalation or skin absorption. It will not protect against the effects of the more powerful penetrating forms of radiation.

Etiological Effects

- The exposure to a micro-organism, of its toxin, that may result in a severe, disabling disease.
- Examples:
 - Hepatitis
 - AIDS
 - Tuberculosis
 - Typhoid
- These hazards are present in biological and medical laboratories or when dealing with people who are carriers of such diseases.
- Most of these diseases are carried in the body fluids and are transmitted by contact with the fluids.
- In most cases, simple protective garments provide an effective barrier against these fluids.

Other Effects

- **Irritants**
 - Primarily affect the respiratory system.
 - Toxins that cause temporary but sometimes severe inflammation to the eyes, skin or respiratory tract.
 - Gives off vapors that attack the mucous membranes of the body such as the surfaces of the eyes, nose, mouth, throat and lungs.
 - Three types of respiratory irritants:
 - Upper respiratory tract
 - Lower respiratory tract
 - Deep (terminal) respiratory tract
- **Sensitizers/Allergens**
 - Cause an allergic reaction after repeated exposure.
 - Some individuals exposed to a material may not be abnormally affected at first but may experience significant and dangerous effects in the presence of the material if ever exposed again.
 - An example is an individual's severe reaction to a subsequent bee sting.
- **Convulsants**
 - Poisons that will cause an exposed individual to have seizures. A sense of suffocation, dyspnea and muscular rigidity develop.
 - Spasms that occur can be very painful, they may begin soon after the individual is exposed and occur at varying intervals from 3 to 30 minutes. Death can result from asphyxiation or exhaustion.
 - Some materials that are considered convulsants are strychnine, organophosphate, caramates and infrequently used drugs such as picrotoxin.

- **Chronic Health Hazards**
 - Permanent and irreversible conditions
 - Three types of chronic health hazards:
 - Carcinogens
 - Mutagens
 - Teratogens
 - **Carcinogens**
 - Cancer-causing agents.
 - Exact data is not available on the amounts of exposure needed for individual chemicals to cause cancer. However, exposure to only small amounts of some substances for a short time can cause long-term consequences.
 - Examples of known or suspected carcinogenic hazardous materials are:
 - Polyvinyl chloride
 - Asbestos
 - Some chlorinated hydrocarbons
 - Arsenic
 - Nickel
 - Some pesticides
 - Many plastics
 - Some carcinogens may be contained within smoke.
 - The ultimate problem with carcinogenic materials and other poisons is the unknown long-term effects of exposure. Disease and complications can occur as long as 20 years after the exposure.
 - It is extremely important that appropriate PPE including SCBA be worn at all fires and haz-mat emergencies.
 - **Mutagens**
 - Materials that cause changes in the genetic system of a cell in ways that can be transmitted during cell division.
 - Exposed individuals may transmit undesirable mutations to a later generation. The person exposed to the mutagen may not be hurt, but his or her offspring can be.
 - Examples:
 - Radiation
 - Benzene
 - Ethylene oxide
 - **Teratogens**
 - Cause congenital malformation--A teratogen will interfere with the normal growth of an embryo, causing malformations in the developing fetus. If administered to or absorbed by pregnant women, they produce a deformed offspring.

- Some materials classified as teratogens are:
 - Ionizing radiation
 - Ethyl alcohol
 - Methyl mercury
 - Thalidomide
 - Dioxins
 - Some infections, such as rubella, are also classified as teratogens
- The major difference between a teratogen and a mutagen is that a mutagen affects the genetic system and a teratogen does not. A teratogen is not hereditary, whereas a mutagen's effects may be.

Routes of Entry

- A hazardous material may enter the body through each of these methods:
 - Inhalation
 - Ingestion
 - Injection
 - Absorption
- **Inhalation**
 - The process of taking in materials by breathing through the nose or mouth.
 - Hazardous vapors, smoke, gases, liquid aerosols, fumes and suspended dusts may be inhaled if SCBA is not worn.
- **Ingestion**
 - The process of taking in materials through the mouth by means other than simple inhalation.
 - Ways that ingestion can occur
 - Poor hygiene after handling a hazardous material.
 - Eating, drinking and smoking contaminated products.
 - Particles of insoluble materials become trapped in the mucous membranes and are swallowed after being cleared from the respiratory tract.
 - Tobacco, food and drinks should be prohibited in the haz-mat incident area.
 - Use extreme caution in obtaining and dispensing drinking water. Water should be drawn from a known clean source and dispensed in disposable cups to reduce the risk of internal contamination.
 - Make sure that all first responders are completely decontaminated and have clean hands before eating.

- **Injection**
 - The process of taking in materials through a puncture or stick with a needle.
 - The hazardous material can be injected into the blood stream, skin, muscle or any place a needle can be inserted.
- **Absorption**
 - The process of taking in materials through the skin or eyes.
 - Some materials easily through areas of the body where the skin is the thinnest, allowing the least resistance to penetration.
 - Areas of concern are:
 - Eyes
 - Wrists
 - Neck
 - Hands
 - Groin
 - Underarms
 - Breaks in the skin
 - Many poisons are easily absorbed into the body system in this manner. Others can enter the system easily through the unknowing act of touching a contaminated finger to one's eye.

Effects of Exposures

- Hazardous materials have varying effects on the body.
 - Many materials, such as asbestos, mercury, silica and heavy metals, attack the body internally but have no external effect.
 - Other materials, such as chlorine, sulfuric acid, anhydrous ammonia and isopropyl alcohol, affect the body both internally and externally.
- Hazardous materials produce a wide range of physical symptoms. Symptoms may not be immediately apparent and can be masked by common illnesses like the flu or by smoke inhalation.
- Some general symptoms of exposure to hazardous materials include the following:
 - Confusion, light-headedness, anxiety and dizziness
 - Blurred or double vision
 - Changes in skin color or blushing
 - Coughing or painful respiration
 - Tingling or numbness of extremities
 - Loss of coordination
 - Nausea, vomiting, abdominal cramping and diarrhea
 - Changes in behavior or mannerisms
 - Unconsciousness
- At the first signs or symptoms of exposure, first responders and their partners should withdraw to the predetermined safe area. Upon withdrawal, they should report this condition immediately.

Summary

1. Name the seven ways that a first responder may be exposed to a hazardous material.
2. Name the four conditions that heat exposure can cause and the symptoms of each.
3. What are some of the ways to prevent and/or reduce the effects of heat exposure?
4. Name the four conditions that cold exposure can cause and the symptoms of each.
5. What are the two classes of asphyxiants?
6. What are the five basic types of radiation and how does each affect the body?
7. What are the three ways to provide protection from external radiation during an emergency?
8. Name the diseases associated with etiological events.
9. What are the other hazards associated with hazardous material incidents?
10. Name three chronic health hazards associated with hazardous materials exposure.
11. How do hazardous materials enter the body?
12. Name some of the general symptoms of exposure to hazardous materials.