Module 3:

Health and Safety

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Module Description

This module addresses health and safety issues by classes of chemicals, and toxic effects on specific body systems. Medical surveillance and proactive health and safety planning are also covered.

Prerequisites

- Students should have completed a hazardous materials operations level training program.
- Students should be certified emergency medical technicians or paramedics.
- Students should have access to the equipment and materials common to a fire department EMS unit.

Objectives

Upon completion of this module, participants will be able to:

Objectives	NFPA Standards	OSHA Standards
• Describe the risk/benefit approach and how it applies to decision-making during emergency incidents.	NFPA 1500 6-2.1.1	29 CFR 1910.120 (q) (6) (iii) (E)
• List the key elements of a proactive health strategy.	NFPA 1500 9-2.1	29CFR1910.1200 (h) (3) (ii)
• List the key elements of proactive safety strategy.	NFPA 1500 9-2.1	29CFR1910.1200 (h) (3) (ii)
• List basic health and safety principles.		
• Define hazardous materials toxic effects terms.	NFPA 1582	29CFR1910.1200 (h) (3) (ii)
• Discuss the elements of medical surveillance.	NFPA 1500 8-1.3	29CFR1910.1200 (h) (3) (ii)
• Explain the basic toxic effects on the human body.	NFPA 473 3-2.1 (d)	29CFR1910.1200 (h) (3) (ii)
• Describe the toxic effects in specific organ systems.	NFPA 473 3-2.1 (d)	29CFR1910.1200 (h) (3) (ii)
• Discuss toxicity specific to the DOT classes of hazardous materials.	NFPA 472 3-2.3.8	29CFR1910.1200 (h) (3) (ii)

Instructor Preparation

Obtain and become familiar with the following regulations:
NFPA 473
NFPA 1500
NFPA 1580
CFR 1910.120
CFR 1910.1200
CFR 1910.20
CFR 1910.3040
CFR 54.390
IAFF Wellness Initiative

Obtain a facility preplan for a site in the local area and become familiar with it.

Research the most prevalent health and safety hazards in the local area. (For example, pesticides may be a significant hazard in agricultural areas.)

Data on local fire fighter illnesses and injuries on duty may be beneficial.

Find out about departmental Employee Assistance Programs (EAPs), community clinics, city-sponsored organizations, or any other programs designed to help people maintain a healthy lifestyle.

Plan on giving the Prerequisite Quiz at the beginning of this module. If any students fail to answer at least half the questions correctly, they should be directed to read *Training for Hazardous Materials Response: Your Rights and Responsibilities* and *Hazardous Materials Training for First Responders (Unit 3-Hazardous Materials)*. Both programs are available through the IAFF's Hazardous Materials Department.

This module requires that students be certified EMTs or paramedics. Consequently, much of the information reviews material in EMS training. If possible, find out how much experience and knowledge your students have to gauge the level of detail you need to teach.

Equipment and Supplies

- IAFF Fire Fighter Line of Duty Death and Injury Investigation
- Transparencies and overhead transparency projector
- Chalkboard or flip chart
- Copies of the NIOSH Pocket Guide to Chemical Hazards
- DOT placards for the nine hazardous materials classes
- Copies of your department's medical surveillance plan and related forms
- Copies of a comprehensive site pre-plan
- "Silly String" or other non-staining substance to spray on clothing
- Air freshener
- Materials for Application Exercise (at end of module before appendices)
- VCR and videotapes:
    - *Team Member: Health and Safety (*formerly *Exposure and the Body's Response)*
    - *Salem, NH Nitric Acid Spill*
    - *Team Member: Medical Surveillance*
    - *Wellness/Fitness Initiativ*e

Approximate Length

This module requires six to eight hours to complete. Fewer hours may be needed if the class is experienced and up-to-date on EMS.

Module 3
Prerequisite Quiz

1. Medical surveillance for emergency responders is part of which federal regulation?
   A. NFPA 1500
   B. NFPA 473
   C. 29 CFR 1910.1200
   D. 29 CFR 1910.120

2. The primary route of chemical exposure for fire fighters is:
   A. Inhalation
   B. Skin absorption
   C. Ingestion
   D. Injection/puncture

3. Secondary contamination refers to:
   A. Contamination from a second chemical during one incident
   B. Contamination of the public
   C. Contamination from someone who has already been contaminated
   D. Contamination from more than one source

4. Which of the following statements is not true of the skin?
   A. Intact skin is usually a good barrier to chemicals.
   B. Skin can be both a route of entry and a target site for chemicals.
   C. Water-soluble substances are more easily absorbed by the skin.
   D. Areas of the body with more hair follicles allow greater chemical absorption.

5. Which of the following items will provide minimum shielding from gamma radiation?
   A. Several inches of lead
   B. Chemical protective gear
   C. Bunker gear
   D. Nothing can protect you from gamma radiation

6. Under federal regulations, medical surveillance is required for:
   A. All fire fighters
   B. Members of EMS and hazardous materials teams
   C. Members of EMS teams only
   D. Members of hazardous materials teams only

7. Biological monitoring measures:
   A. The amount of absorbed radiation
   B. The amount of an agent in your body
   C. Chemical exposure over long periods of time
   D. Baseline body chemistry

8. Simple asphyxiants displace oxygen in the air. Chemical asphyxiants:
   A. Absorb oxygen in the air
   B. Combine with oxygen molecules to create a chemical reaction
   C. Prevent the respiratory system from inhaling oxygen
   D. Prevent the body from using inhaled oxygen

9. Etiologic means that an agent is:
   A. Airborne
   B. Bloodborne
   C. Infectious
   D. Carcinogenic

10. Which of the following organs is considered the primary "transfer point" for chemicals in the body?
   A. The heart
   B. The brain
   C. The gastrointestinal system
   D. The lungs

Introduction

Questions

1. *What are two common examples of chemical asphyxiants?*

2. *What are mutagens?*

3. *Which of the following is a standard, and which is a guideline?*
   Threshold Limit Value (TLV)
   Permissable Exposure Limit (PEL)
   Short Term Exposure Limit (STEL)
   Immediately Dangerous to Life or Health (IDLH)

4. *OSHA/EPA requires employers to maintain medical records on exposed workers for how many years?*

Making a safe and effective emergency response at the technician level requires a complex approach that integrates personnel, protective equipment and other resources. The most important resources at the scene of any emergency, including one involving hazardous materials, are the fire fighters and paramedics who will do the work.

An effective response begins long before the incident with a set of initiatives that helps guarantee the long term health of team members. Emergency response is characterized by a high stress environment where many unknowns are at work. Responders must be able to quickly size up the situation and implement protective measures. Being effective in this high pressure role means making sure you operate at peak effectiveness. No one can operate at peak efficiency without good health.

Health and Safety

Emergency Responders and Health

Good health is characterized by physical and mental well-being. It's the absence of disease, injury and pain. Good health allows us to perform at our highest level and to enjoy what we do. Having good health is not a chance occurrence. For most of us it means being aware of our bodies and making wise decisions that take into account the stresses we are under in our work. Few professions are more stressful than fire fighting and emergency response. As a result, good health is extremely important.

Emergency Responders and Safety

It is widely recognized that fire fighting and emergency medical response, including hazardous materials emergencies, is highly dangerous work. The rate of worker injury is high; about 25% are injured each year. Some of these injures are serious, resulting in disability retirement. In addition to these injuries, members are constantly exposed to hazardous materials and other emergency events that take a toll on their long term health.

While you often operate in a chaotic environment, you must always work safely. This includes making the scene as secure as possible while reducing the opportunity for injury to occur. Professional response personnel understand that many elements of emergency response can be identified and planned for in advance.

Proactive Hazardous Materials Emergency Response

To the public, fire department actions at the scene of a burning gasoline tanker might seem confused and chaotic. Dozens of fire fighters moving quickly, thousands of gallons of foam in all directions, hoselines scattered everywhere—only a trained professional would look at the same scene and see a carefully planned event that includes a coordinated attack using well managed resources. They would see that the coordination involves downhill control of the product and that there are sufficient resources on scene to allow for effective rehabilitation of crews working in the Hot Zone. While it may be an emergency event in the eyes of the public, professional responders have carefully planned in advance the key elements of the response that will ensure the health and the safety of fire fighters and paramedics. It's what is known as proactive planning. Proactive planning means identifying key needs and creating a strategy to meet them before they arise. You may not know exactly when the specific emergency will occur, but you can identify in advance many of the things you will need to respond effectively and safely. Chief among these needs is good personal health.

As an emergency responder you are constantly risking your personal health and safety to complete objectives at an emergency incident. A key component of an effective health and safety strategy is ensuring that these risks are appropriate. The only way to know if the risk is appropriate is to understand the benefit.

The Risk/Benefit Approach

All risks on an emergency scene are not equal. Some of them, like securing the scene or shutting down the fuel flow from a remote location, can be achieved with little personal danger. Other actions, such as moving directly into the Hot Zone to stop a leak or attempt a rescue can put emergency responders at extremely high risk. If anything goes wrong,

or if there is a rapid change in conditions, responders can be killed or injured.

Unfortunately, there are many instances where fire fighters have either died or been seriously injured taking risks that were not equal to the benefits that would likely result from their actions. Often these events involve close-up fire suppression in areas where there was little if any life threat to the community. In many instances the only lives endangered in the event were those of response personnel. The saving of any amount of property is not worth the life of an emergency responder.

Accordingly, you need to always ask yourself: What risk am I taking, and what benefit can I expect to receive? If risks outweigh benefits, you should reduce the risk. Generally speaking, fire fighters should only be exposed to low risk to save property. They may be put at slightly higher risk in marginal rescues where a professional evaluation concludes that there is not a high probability that the victim will survive. Responders should be put at high risk only if there is a clearly savable life.

A risk/benefit assessment means that members must carefully evaluate an incident, including patient viability and adequacy of emergency resources to safely handle the event. If proper resources are not present or if the rescue is extremely complicated with little chance for success, aggressive actions should be carefully scrutinized.

Activity

Hazardous Materials and Their Effect on the Human Body

The next step in understanding and preventing hazardous materials exposure is to review a substance's overall effect on the body and specific body systems. We can also learn about toxic exposure by studying some of the hazards presented by each of the nine classes of hazardous materials. This approach provides a broad picture of exposure concerns and organ systems, then links these issues to DOT hazardous materials classifications.

Categories of Toxic Substances

Asphyxiants

Asphyxiants deprive the body of oxygen. The normal concentration of oxygen in air is 20.9 %. Lower concentrations result in an oxygen-deficient atmosphere, especially if oxygen content is less than 19.5 %.

There are two types of asphyxiants: simple and chemical. Simple asphyxiants simply displace oxygen in the environment. Examples of common simple asphyxiants include carbon dioxide, nitrogen, methane, propane, and argon.

Chemical asphyxiants prevent the body from using oxygen, even though it may be present. Carbon monoxide, hydrogen sulfide, and hydrogen cyanide are examples.

Signs and symptoms of oxygen deficiency include progressive problems such as: restlessness, agitation, drowsiness, confusion, stupor, coma, and death. Some asphyxiants can also create other hazards such as flammable atmospheres that may initially be above the flammable range but become flammable during operations.

Confined spaces such as tanks, underground areas and enclosed rooms are especially hazardous. Without self-contained breathing apparatus, you can be quickly overcome in an oxygen-deficient atmosphere.

Equipment that measures the oxygen level is becoming increasingly available to technicians. Always remember to monitor in teams of two and be aware that a decreasing oxygen reading can mean the presence of a lethal gas with multiple hazardous properties.

Corrosives

Corrosives are divided into two categories: acids and bases. A primary danger from corrosives is that they can cause irreversible tissue damage. Their effects depend on the **concentration** of the material, that is, the amount of product in solution (for example, 40% hydrochloric acid, or 80% sodium hydroxide) and the strength of the acid or base. Hydrochloric acid, for instance, is a stronger acid than acetic acid and is consequently more toxic.

The skin, eyes and mucous membranes of the upper respiratory system are all very sensitive to corrosives. Acids tend to cause irritation, pain, or a burning sensation upon contact. Bases, or alkalis, can cause tissue destruction that may initially be painless. If inhaled, general signs of respiratory tract irritation may include coughing or difficulty breathing. Skin or eyes affected by acids or alkalis should be decontaminated with large amounts of water as soon as possible. Structural fire fighter protective clothing will provide limited protection against corrosive exposure. The effects of corrosives, however, will affect the thermal properties of the garment.

Irritants

Irritants cause temporary, but occasionally severe, inflammation of the eyes, skin, or respiratory tract. There can be permanent damage if exposure is repeated over time. Symptoms depend on the tissue that is affected. You may be familiar with the itching, redness, and discomfort of irritated skin and eyes. Coughing and difficulty breathing are symptoms of respiratory exposure to an irritant. Many solvents, such as benzene, cause skin irritation. Other

irritants include ammonia, chlorine, and hydrogen chloride. Keep in mind that these substances have other toxic properties as well.

Sensitizers

Sensitizers cause allergic reactions after repeated exposures. A reaction can appear several hours after exposure to a sensitizing agent. In case of skin exposure, a rash may not appear until several hours after exposure. Reactions vary depending on the route of exposure and an individual's susceptibility to a specific toxin. Allergic reactions tend to become worse with repeated exposures. Inhalation may cause an asthma-like reaction in the short term with longer term exposures resulting in permanent lung disease.

Examples of sensitizing agents include: formaldehyde, mercury, and toluene diisocyanate (TDI).

Carcinogens

Carcinogens cause cancer. Some carcinogens have been definitely linked to cancer in humans. Others are known to cause cancer in laboratory animals and are suspected of causing cancer in humans. Studying the cancer-causing potential of chemicals is difficult since the latency period (the time that it takes cancer to develop) can be up to 30 years. The exact levels of exposure can be difficult to document. Very little is known about the health effects of exposure to multiple carcinogens. Fire fighters and emergency responders may be exposed to multiple carcinogens during fire fighting or hazardous materials response.

Carcinogens may affect an organ or organs remote from the route of entry. Some examples include benzene, which is associated with leukemia; vinyl chloride, which is associated with a specific type of liver cancer; and asbestos, which causes a specific type of lung cancer and increases the risk of all lung cancers among exposed individuals, particularly those who smoke. Other examples of cancer causing agents include coal tar and cigarette smoke.

Neurotoxins

Neurotoxic chemicals can cause both temporary or permanent damage to the central nervous system (the brain and spinal cord) or the peripheral nervous system (the nerves responsible for sensation and movement in the arms, hands, legs, and feet). Exposures to neurotoxins during an emergency are likely to be short-term and high-level.

Many solvents are neurotoxic. Their effects include dizziness, euphoria, and impaired judgment and reflex time. Pesticides are common neurotoxic chemicals that can have system-wide effects including loss of muscle control, wheezing, muscle tremors and gastrointestinal disorders. Some neurotoxins are also convulsants, which produce seizures. These include chlorinated hydrocarbon insecticides such as aldrin and dieldrin; halogen fumigants such as methyl bromide and sulfuryl fluoride; organophosphates such as diazinon and dursban; and solvents such as phenol, ethylene oxide, and carbon disulfide.

Mutagens

Mutagens are toxic agents that cause genetic changes. These changes occur in the genetic material in eggs and sperm. As a result, the characteristics of future generations can be altered after exposure to mutagens. For example, one of the hazards of radiation exposure can be genetic alterations. Such hazards were apparent after the nuclear reactor incident at Chernobyl where thousands of people were exposed to significant amounts of radiation in the days and weeks after the explosion.

Examples of mutagens include ethylene oxide, ionizing radiation, hydrogen peroxide, and benzene.

Teratogens

Teratogens are substances that cause malformations in an unborn child. Fetuses are particularly susceptible to hazardous materials exposure because their cells are developing and reproducing at a very high rate. Examples of teratogens include anesthetic gases, organic mercury compounds, ionizing radiation and German measles.

Infectious Agents

Infectious agents gain access to the body primarily through inhalation, ingestion, and absorption through the skin. Many infectious agents have a preferred route of entry. Infectious agents include viruses such as hepatitis A, hepatitis B, hepatitis C, human immunodeficiency virus (HIV), and the herpes virus. Avoiding exposures to blood and body fluids by using body substance isolation (BSI) can help to protect you from exposure. Body substance isolation can be defined as the use of personal protective equipment and procedures designed to protect emergency responders against exposure to infectious agents. EMTs and paramedics should be thoroughly familiar with these procedures.

Bacteria are also infectious organisms that can cause disease in humans. Different types of bacteria cause tuberculosis, strep throat, and most wound infections. Tuberculosis infections are increasing and should be of concern to responders who have direct patient contact. Routine tuberculosis screening can detect infection early, so the disease can be promptly treated. Your department and participating health care facilities must have procedures for follow-up if you are in direct contact with a patient infected by tuberculosis.

Other organisms include fungi (plant-like organisms that cause disease, such as oral thrush and athlete's foot), parasites (organisms that live on other organisms, such as those that cause trichinosis and dysentery), and rickettsia (microorganisms transmitted by insects, such as the tick that carries Lyme disease).

Activity

The Language of Hazardous Materials Toxicity

There are a number of good reasons why you should understand toxic effects. Even though you may operate safely and efficiently, there is an still an opportunity for exposure. You already know that routine structural fire fighting results in exposures to toxic materials. If you are also engaged in hazardous materials response at the Technician level, your potential for exposure increases.

A high profile element of a safe response is the ability to thoroughly research a toxic material as part of incident response. Research will help you better determine the toxic properties of the material(s) involved in the incident. Knowing and understanding key terms and principles can help in your research.

Toxicological Terms

Toxicology: The study of poisons

Toxicity: The inherent capacity of an agent to produce injury

Toxin or Toxicant: An agent or substance capable of causing harm

Exposure: The process in which a toxicant reaches a susceptible body tissue

Target organs: The organs that are selectively affected by a particular agent or substance

What Makes a Substance Toxic?

For a substance to be considered toxic it must have certain properties and be present under certain conditions. These properties and conditions work in concert to create a negative health effect. Toxic materials must:

- Have **physical and chemical properties** capable of causing harm. Many times, solid materials are less toxic than gases because their potential to spread easily and cause harm is much less. Chlorine gas can diffuse rapidly and is extremely toxic in even small amounts.

- Be present in **sufficient amounts to do harm**. That is, the **dose** must be large enough. Carbon dioxide in small amounts is virtually undetectable. However, in larger quantities it can replace oxygen in the atmosphere and result in asphyxiation.

- Be present for a **sufficient amount of time**. Some materials pose little threat if the exposure time is small. However, remaining in the contaminated area for extended amounts of time can result in significant exposure. Prolonged exposure to such common hazardous materials as gasoline can result in chemical burns and long-term health effects such as cancer.

- Have **a route of entry** into the body. Intact skin is a good barrier because it provides some protection against exposure. Intact skin is not, however, a replacement for proper personal protective equipment. Some materials such as solvents can be easily absorbed through the skin and damage target organs such as the liver.

- Reach **a susceptible body organ or tissue**. Many materials have an affinity for specific body organs. Tuberculosis, an increasingly common infectious agent spread through respiratory contact, lodges in the lungs and can result in serious disease if undetected.

Exposed, Contaminated, or Both?

Understanding the difference between exposure and contamination will help you avoid the negative effects of toxic materials.

Exposure

Although there is often overlap between exposure and contamination, it is possible to distinguish between the two. If you enter a confined space where carbon monoxide is present, without sufficient respiratory protection, you breathe these fumes into your lungs. You are *exposed* to the material and the toxic effects that it produces. If you remain in this atmosphere for a sufficient amount of time, you will begin to suffer the negative effects of exposure to carbon monoxide. If, however, you leave the area and return to fresh air, you are no longer in the presence of the gas and the exposure stops. You have been exposed to the gas by being in the area and breathing it into your body.

> *Exposure occurs when a toxic substance or infectious agent is taken into the body or is in direct contact with the body.*

Contamination

If, during the course of operations at a large flammable liquid spill, you saturate part of your clothing with the product, you are contaminated. This hazardous material will remain on your clothing and possibly on your skin until you take steps to leave the area and remove the contaminant. You have been contaminated with the material and you may be receiving an exposure if the material is on, or in the body.

> *Contamination occurs when the material clings to or saturates clothing, or parts of your body.*

It is possible to be contaminated at an incident *without* being exposed if you are using the correct personal protective equipment in the Hot Zone and you undergo thorough decontamination when you have completed your assignment.

Similarly, it is possible to be exposed to a hazardous material but not contaminated by it. One example would be conducting rescue operations in close proximity to a sealed source emitting radioactive gamma rays. You are exposed to the powerful wave of energy from the source, but when you leave the area, you are not contaminated.

Understanding these principles helps you avoid the negative health effects of hazardous materials.

Determining Toxic Effects

If you have been exposed to a hazardous material, you need additional information to determine its likely effects.

Potential toxic effects. You must know how the specific material will harm the body once it enters. Later sections in this module discuss how some materials target different body systems and how some classes of hazardous materials also have specific health effects.

Amount present. Estimating or determining the amount of toxic substance involved can provide important information about the severity of the effects.

Route and conditions of the exposure. Knowing *how* the material entered the body provides clues to the body tissues it will affect, and to what degree.

Characteristics of the susceptible person. Some persons are more susceptible to exposure than others. Young children and persons with pre-existing medical conditions can be especially vulnerable. Knowing these individual characteristics can help you estimate the severity of the exposure event.

Concentration and Duration

Two of the most important factors determining chemical toxic effects are concentration of the substance and duration of the exposure.

The **concentration** of vapors and gases is measured in parts of vapor or gas per parts of air (by volume). The standard units of measure are parts per million (ppm) and parts per billion (ppb). For example, a carbon monoxide concentration measured as 1,500 ppm contains 1,500 parts of carbon monoxide for every 1,000,000 parts of air.

Concentrations of solids can be measured according to the weight per volume of air—milligram/cubic meter (mg/m^3). Solids suspended in air can be dusts, mists and fumes. Though ammonia is primarily an irritant gas, at a high enough concentration (around 150,000 ppm) it becomes a *flammable* gas, creating a whole new set of hazards for hazardous materials technicians.

Duration refers to the length of contact with a substance. Duration is one factor affecting how much is absorbed. Longer and more frequent exposure periods usually result in greater absorption.

The dose of the agent is how much of the agent reaches a target organ. The higher the concentration and longer the duration of exposure, the higher the dose.

The severity of effects depends on the situation. For example, exposure even to low concentrations of most toxic products of combustion will produce severe health effects if the exposure occurs over a long enough duration. On the other hand, a very short duration exposure to high concentrations of toluene can produce severe effects as well.

Acute and Chronic Exposures

The toxic effects of hazardous materials can result from acute or chronic exposure.

Acute

Acute exposure occurs over a short period of time to a relatively high concentration of a substance. An acute exposure may have effects that are both immediate and long-term. For example, the immediate effects of acute exposure to carbon monoxide include headache, weakness, dizziness, and loss of consciousness. Days or weeks after "recovery" from the initial exposure there may be delayed symptoms of brain impairment such as confusion, lack of coordination and behavioral changes. Other effects from acute exposure may not be detected until years later.

Chronic

Chronic exposures are long-term (over several days to weeks or longer) and involve repeated periods of contact at relatively low concentrations.

Effects of Acute and Chronic Exposures

In many cases, the effects of acute exposure are very different from the effects of chronic exposure. For example, the primary acute toxic effect of benzene exposure is central nervous system (CNS) depression, whereas chronic exposures to benzene can cause leukemia. Acute exposure to carbon monoxide causes asphyxiation, while chronic exposure can cause heart problems.

Measures of Toxicity

The toxicity of a substance is usually determined through cell or animal testing. A frequently used measure is **LD_{50}**. This is the **lethal dose** for **50%** of the animals being tested under specific conditions. Other measures include LD_{100}, the lethal dose for 100% of the population studied, the LC_{50} and LC_{100}, the **lethal concentrations** of a substance that will kill 50% and 100% of the population, respectively.

These measures are often found in references and indicate a relative toxicity, that is, the toxicity of one substance compared with another. A substance whose LD_{50} is 0.5 mg (of substance) per kilogram (of animal body weight) is considered much more toxic than one with an LD_{50} of 2.0 mg/kg. The lower the LD or LC, the higher the toxicity.

There is almost no reliable information about the toxic effects of combinations of chemicals. For this reason, take every precaution to avoid exposure.

Standards and Guidelines Related to Toxic Exposure

Threshold Limit Value (TLV), Permissible Exposure Limit (PEL), Short Term Exposure Limit (STEL), and the Immediately Dangerous to Life or Health (IDLH) level are key terms describing standards and guidelines related to the exposure limits of hazards. Some of these levels are determined by the relationship between the dose of the substance and the resulting toxic effect. Most are based on time-weighted averages unless otherwise noted.

LIMIT	EXPOSURE DURATION	IS IT LAW?	COMMENTS
TLV	8 hours/day up to 40 hours/week	NO	Determined by a professional organization
PEL	8 hours/day up to 40 hours/week	YES	Set by OSHA
STEL	15 minutes	YES	Set by OSHA
IDLH	30 minutes	NO	Determined by NIOSH - for escape only
REL-TWA	up to 10 hrs/day during 40 hrs/ week	NO	Determined by NIOSH

Threshold Limit Value (TLV) is the average airborne concentration of substances to which it is believed nearly all adults may be repeatedly exposed in the working environment for an eight hour workday or a forty hour work week, without adverse effects. However, maintaining levels below these levels does not guarantee there will not be any adverse effects. The Threshold Limit Value, Ceiling (TLV-C), or ceiling level, refers to the level that should *never* be exceeded, even for a moment. TLVS are reviewed and updated annually.

Permissible Exposure Limit (PEL) is the average airborne concentration of a potentially toxic substance to which an employee may be exposed for an eight-hour period. This standard is the legal limit of exposure allowed in a workplace according to a federal law, the Occupational Safety and Health Act. Most of these limits were adopted from existing TLVs.

Short Term Exposure Limit (STEL) is a standard or legal limit, like the PEL. The maximum duration of exposure at this level is usually 15 minutes with no more than four exposures in an eight-hour day and one hour between exposures. At the STEL, it is believed that exposure will not result in permanent damage. There is no margin of error in the STEL, and individuals who are more susceptible may experience toxic effects at lower levels.

The **Immediately Dangerous to Life or Health (IDLH)** level is defined as "a condition that poses a threat of exposure to airborne contaminants when that exposure is likely to cause death or immediate or delayed permanent adverse health effects or prevent escape from such an environment." Substances that are suspected to cause cancer generally do not have IDLH levels since there is a potential for developing permanent health effects.

These standards (legal limits) and guidelines (recommended limits) should not be regarded as the division between "safe" and "dangerous" levels. These levels are only defined for single levels. They do not account for exposure to multiple toxicants. Sometimes the combined toxic effects of substances is far greater than the individual properties of the materials. As an example, smokers with a history of asbestos exposure are at much greater risk for

cancer than nonsmoking asbestos workers or smokers who are not exposed to asbestos. Because they are routinely exposed to asbestos during overhaul and other fire fighting duties, fire fighters should not smoke.

Activity

How Toxic Materials Enter the Body

There are four major routes of exposure: skin absorption, inhalation, swallowing (ingestion), and injection or puncturing. The eyes can also be a route of toxic exposure.

Skin Absorption

Toxic substances can be absorbed through the skin, or may enter the bloodstream through broken skin. The skin can act as a barrier to provide varying degrees of protection. The longer a material is in contact with the skin, the greater the amount absorbed. The higher the concentration of the chemical, the greater the amount absorbed. Skin temperature and blood flow also affect the rate of absorption. Areas with hair follicles allow for greater absorption. For example, the scrotum is 300 times more susceptible to absorption than the foot. The type of chemical also affects exposure. For example, fat soluble chemicals, like solvents, are more readily absorbed. The integrity of the skin can be damaged by trauma, heat/cold, humidity and moisture, and previous chemical exposures.

Inhalation

The lungs act as a transfer point in the human body. Chemicals and infectious agents can enter the body through inhalation. The rate and depth of respiration affect the amount of the material absorbed. Faster and deeper respiration rates increase exposure. This route of exposure is most common for fire fighters unless SCBA is used.

Ingestion

Toxic materials can be swallowed if contaminated hands or clothes come in contact with the mouth. Ingested materials can affect other organs as well as the gastrointestinal system. To avoid exposure through ingestion, always complete decontamination before you eat or drink.

Injection and Puncturing

Injection or puncturing can be:

- Intradermal (into the skin)
- Subcutaneous (under the skin)
- Intravenous (into a vein)
- Intramuscular (into a muscle)

Injections and punctures result from contact with physical agents such as syringes, high pressure devices or sharp objects (e.g., jagged pieces of glass or metal). Injuries from injection and puncture can be more serious than surface contact because chemicals can penetrate deep into the tissues. Consequently, it may be difficult to determine the extent of the exposure. Injection also damages the integrity of the skin, allowing an opening for other chemicals.

The Eyes

Up to 90% of hazardous materials can be absorbed through the eyes. Only 10% of all eye injuries involve hazardous chemicals, however, with chemical burns causing the most severe injuries. Chemicals that are both water and fat soluble penetrate the farthest and do the most damage. Most chemical injuries to the eye are caused by alkali splashes. Common chemical injuries involving the eye include: lye, quick lime, ammonia, sulfuric acid, and hydrocarbons.

Activity

Toxicity Specific to Classes of Hazardous Materials

DOT classes describe the most significant hazard associated with a regulated substance. These materials may pose multiple hazards. For example, uranium hexafluoride, which has a primary hazard of radiation, is also corrosive. A knowledge of chemistry is extremely important in understanding hazard classes.

Explosives and Blasting Agents Class 1

Many of these agents contain nitrates, which cause dilation of blood vessels. Symptoms include headache, nausea, abdominal cramping, and reduced blood pressure. Severe exposures can cause heart irregularities and shortness of breath. If inhaled or absorbed, nitrates can cause eye and skin irritation as well as reducing the capacity of red blood cells to carry oxygen. Explosives with names containing "azo-" and "azid-" can emit toxic fumes of nitrogen oxides when they heat and decompose. These oxides can produce severe lung injury.

Poison Gases and Poison Class 2, Division 2.3 Class 6, Division 6.1

Poison Gas, Class 2, Division 2.3 materials are extremely toxic and a small amount of vapor or gas is dangerous to life. Cyanogen gas, phosgene gas, and organic phosphates mixed with compressed gas are included in this category. The primary route of exposure is inhalation. Even brief or low-level exposure requires immediate attention in a hospital.

Materials classified as Poisons, Division 6.1 are considered somewhat less dangerous than those classified as poison gas because they exist in either a solid or liquid state.

Solids and liquids are not inhaled as readily as gases, but they still pose a significant hazard. Arsenic compounds found in liquid or solid state, such as arsenic iodide, or even pure arsenic in its solid form, are classified as poisons. Yet arsine gas results from the combination of these materials. These substances can be absorbed through inhalation, ingestion, or skin absorption and may be highly toxic. Immediate medical attention is required for exposure. Some of these compounds may cause cancer. Other examples of poisons are carbon tetrachloride and hydrocyanic acid.

During a fire, many materials in the poison class can produce gases that would be classified as poison gases.

Flammable Gases Class 2 Division 2.1

Many of these gases displace oxygen and can cause asphyxiation in confined spaces. Acetylene is a simple asphyxiant as well as a narcotic in high concentrations. Another gas, ethylene oxide, produces cancer and birth defects in lab animals and may be a reproductive hazard in humans as well. Ethylene oxide, like many flammable gases, is a strong irritant to skin, eyes, and mucous membranes.

Non-Flammable Gases and Oxygen Class 2 Division 2.2

This class includes oxygen, carbon dioxide, ammonia, and inert gases. Oxygen-enriched environments are not toxic to humans, but the danger of fire is very great. Carbon dioxide and the inert gases are simple asphyxiants, rapidly causing death because they displace oxygen in the atmosphere. Ammonia is extremely irritating and can burn even at relatively low concentrations.

This class also includes the halogen acid gases, such as hydrogen fluoride, hydrogen chloride, and hydrogen bromide. All the halogens (chlorine, bromine, and fluorine) and their acids are highly irritating to the skin and mucous membranes. Inhalation can cause pulmonary edema, which impairs breathing. Any material that reacts with water will react with water found in body tissues.

Flammable/Combustible Liquids Class 3

The majority of these materials are hydrocarbons and hydrocarbon derivatives. Hydrocarbons target several organs and can cause central nervous system depression, resulting in dizziness, lack of concentration, or sleepiness. The peripheral system may also be damaged, affecting both the motor and the sensory nerves. Some hydrocarbons can also cause dysrhythmias. High levels of inhalation exposure can result in irritation of the respiratory tract or pulmonary edema.

Halogenated hydrocarbons are toxic to the liver. Some may cause kidney damage as well. Benzene is a commonly known carcinogen. Chloroform and trichlorethylene are known animal carcinogens and potential human carcinogens. In addition to inhalation exposure to vapors, many of these agents are easily absorbed through the skin. In fact, skin exposure of one hydrocarbon may enhance absorption of other hydrocarbons.

Flammable/Water-Reactive Solids Class 4

Flammable solids include lithium compounds. These compounds can cause irritation to the skin, eyes, and mucous membranes. Some may irritate the lungs if inhaled. Also in this class are some nitrogen compounds that liberate oxides of nitrogen when they decompose in a fire. Several nitrogen compounds cause liver, kidney, cardiac, or central nervous system effects.

Oxidizers and Organic Peroxides Class 5

Oxidizers include several families of agents such as organic peroxides. Organic peroxides can cause skin or mucous membrane irritation, or pulmonary/laryngeal edema. The halogens are also members of the oxidizers class. They are highly irritating to eyes and mucous membranes. In addition, chlorine and fluorine are well known as powerful caustic irritants to tissue.

Other oxidizers include nitrate compounds, as previously discussed. Ammonium compounds are also represented in this class. They can liberate toxic fumes such as ammonia and oxides of nitrogen when they decompose. In addition, some oxidizers, such as ammonium, are possibly carcinogenic.

Radioactive Materials Class 7

Radioactive materials will generally cause long-term or chronic problems rather than short-term effects. Acute effects from high exposures are very rare. Acute exposures can result in neurologic problems, nausea, and vomiting, and skin and mucous membrane irritation. Chronic exposures are generally linked to increased rates of cancer and birth defects.

Corrosives Class 8

The corrosives hazard class includes acids and bases that can cause severe injury to skin and mucous membranes on direct contact. Inhalation of corrosives may damage the lungs, and ingestion may cause severe injury to the gastrointestinal tract.

Miscellaneous Hazardous Materials Class 9

Class 9 includes materials that are hazardous during transport, but are not included in another hazard class. These include anesthetic or noxious materials, as well as those that are subject to DOT requirements for hazardous substances or hazardous wastes. Examples of Class 9 materials include PCBs and molten sulfur.

ORM-D Materials

An ORM-D material presents a limited hazard during transportation because of its form, quantity, and packaging. Small arms ammunition are examples of ORM-D materials.

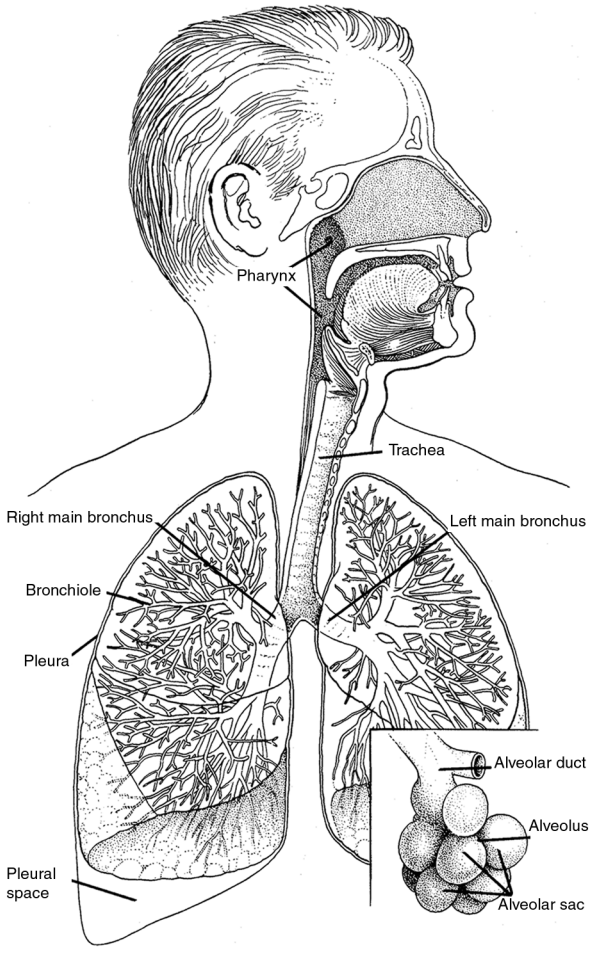
Activity

Toxic Effects in Specific Organ Systems

This section briefly reviews some of the body's major organ systems and how they can be affected by hazardous materials exposure. By understanding your body's response, you can take steps to protect yourself before, during, and after an emergency incident. Remember that *preventing* exposure is the key.

Respiratory System

Major components of the respiratory system include the nose, pharynx, larynx, trachea and lungs.



The upper respiratory system includes the nose and physiological structures down the airway to the larynx. It provides a means for drawing air down into the lungs and provides some protection for the lower respiratory tract. The upper respiratory system is lined with mucous membranes, which can trap foreign matter and deliver it to the digestive tract where it can be safely excreted. Toxic effects on the digestive system are discussed later.

The lower portion of the respiratory tract consists of the trachea, bronchial "tree" and the lungs. The trachea extends from the larynx to the middle of the chest. At that point, it divides into the right and left bronchi. The bronchi are also lined with mucous membranes that trap dirt and other foreign matter. Each bronchus further leads into a grape-like cluster of tiny air sacs called alveoli. Each of these alveoli is enveloped by a network of microscopic blood vessels called capillaries. Oxygen enters the bloodstream by diffusing, or crossing from these air sacs into the capillaries.

The lung is both a route of entry and a target organ. Occasionally, a chemical that will eventually harm the lungs enters through the skin or the mouth. This is a systemic effect, and is the case with the herbicide Paraquat, which can be absorbed through the skin but damages the lungs. More commonly, however, inhaled substances are responsible for direct respiratory system damage.

Factors affecting toxic response in the lung include:

- Rate and depth of respiration
- Duration of the exposure
- Nature and concentration of the exposure
- Route of entry
- Site of deposition

Individual characteristics also affect the body's protective mechanisms and predisposal to injury. Age, genetic background, and other exposures such as smoking are examples of such characteristic factors.

Two chemical properties determine how a substance affects the lungs: solubility and particle size.

Solubility refers to the ability of the substance to dissolve in water. Water soluble chemicals are often rapidly absorbed within the lungs and carried to other parts of the body before damaging lung tissue.

Particle size influences how far a substance penetrates the respiratory system. There are protective respiratory system mechanisms to remove particle deposits from the body. Large particles are trapped in the mouth or nose and removed by nose blowing, sneezing, and swallowing. Smaller particles are removed by cilia in the trachea and bronchial tree. **Cilia** are hairlike projections from cells that beat in a coordinated wave. Cilia move foreign substances up to the throat where they are removed. Most of the smallest particles are removed through cells in the immune system and cilia motion. Protective mechanisms can be weakened by toxic exposure.

Individuals with chronic bronchitis can have narrowed repiratory mucous layer passages. This increases the velocity of particles moving through the airways, and more particles can be deposited. In addition, exposure to irritants can cause bronchial constriction and also increase particle deposition.

Toxic Effects

The responses of the respiratory system to toxic agents generally fall into one of the following general categories:

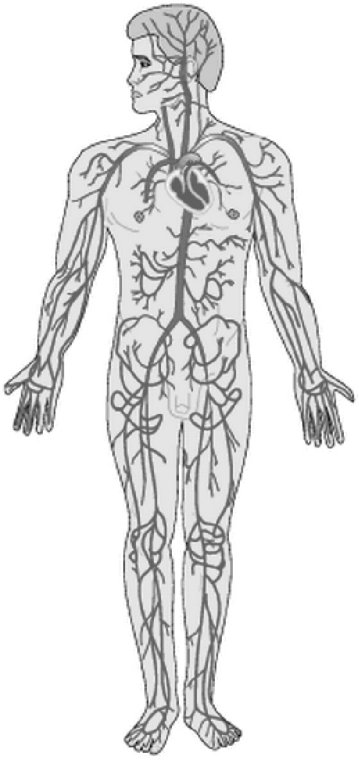
- **Irritation**: Airway constriction, abnormal fluid accumulation, infection and cell damage
- **Sensitization**: An allergic response that can restrict airways
- **Production of fibrosis**: Fibrotic tissue blocking air passages
- **Carcinogens:** Cancer of the lung

Signs and Symptoms

Even though lungs may be damaged in many ways, there are only a few signs and symptoms of injury, such as productive (producing sputum and saliva) or dry cough, or difficult or labored breathing (dyspnea). In some cases breathing becomes more difficult when the person lies down. Breathlessness may be accompanied by increased respiratory rate, posturing (such as hand and arm rigidity, or hand curling resulting from brain stem injury) and cyanosis (the slightly bluish color of skin due to a lack of oxygen).

The Cardiovascular System

The cardiovascular system consists of the heart and a system of blood vessels. This system circulates blood from the heart to the body and vice versa via its extensive network of blood vessels. The main function of the heart is to pump oxygenated blood throughout the body. The heart is a muscle with its own electrical system. Electrical impulses cause the heart to contract, moving blood throughout the body.



The principal types of blood vessels are arteries, capillaries and veins. Arteries carry blood away from the heart to organs and tissues while veins carry blood back to the heart. Capillaries are microscopic blood vessels with thin walls through which oxygen, nutrients, and other materials diffuse. The collection of blood vessels that provides the body's limbs with oxygen and nutrients is known as the peripheral vascular system.

Toxic Effects

Toxic substances may affect the heart or peripheral vascular system. As with many other body systems, the severity of the effect is influenced by the concentration and duration of exposure as well as pre-existing health conditions.

- **Electrical conduction disturbances** are abnormal contractions of the heart muscle, such as potentially life-threatening ventricular tachycardia. Materials that can cause these effects include solvents, carbon disulfide, Freon, and insufficient oxygen.

- **Decrease in the contracting force of the heart muscle** results in an inadequate force to push the blood through the vessels. Ethanol, cobalt, and trichloroethane (TCA) can cause this effect.

- **Enhanced arteriosclerosis** or hardening of the arteries can be caused by carbon monoxide and acrolein.

- **Hypertension** or high blood pressure can be due to a variety of causes. It can lead to strokes, heart disease and kidney failure. Exposure to lead and cadmium are linked to hypertension.

- **Hypotension** or low blood pressure may be seen with toxic exposures that result in dilation of the blood vessels. If the body is unable to compensate for this dilation, shock can result. Nitrates are known to cause these effects.

Signs and Symptoms

Signs and symptoms associated with cardiovascular exposure mimic those seen in medical emergencies involving solvent exposures. They include:

- Irregular or rapid pulse
- Decreased tolerance for exercise or physical activity
- Dizziness and fatigue
- Swelling or edema in the ankles
- Palpitations or the feeling of skipped heart beats
- A feeling of indigestion
- Pain in the chest, jaw, or left arm

Blood and Blood Forming Organs

This body system consists of the blood, bone marrow, spleen, and lymphatic tissue. As with other organ systems, the longer the duration of the exposure, the more severe the toxic response.

Blood consists of red blood cells that transport oxygen and other nutrients to the body; white blood cells that assist the body's immune system; and platelets, which are cell fragments required for proper clotting. These are all suspended in a pale yellow fluid called plasma.

Bone marrow is the spongy center of some bones including the sternum, ribs, hipbones and a few other bones such as the vertebrae, clavicles, and cranial bones. Bone marrow forms all types of blood cells except some white blood cells.

Toxic Effects

The blood system can be damaged by agents that affect bone marrow production, the components of the blood (red and white blood cells and platelets), or the oxygen carrying capacity of red blood cells.

Toxic effects include:

- **Bone marrow suppression**: A decrease in the activity of the bone marrow that leads to decreased blood cell production. Examples include ionizing radiation and benzene.

- **Effects on platelet activity**: Results in a change in the formation of blood clots. Examples: aspirin, which inhibits clotting; benzene, which decreases the number of platelets; and perchlorethane, which increases the number of platelets.

- **An increase or decrease in the number of white blood cells**: An increase occurs with leukemia, which is a result of bone marrow cancer. Benzene and other solvents may cause the white blood cell count to decrease, as can chronic phosphorus exposure. A decrease in white blood cell count impairs the body's ability to fight infection.

- **Effects on the white blood cells responsible for the immune response**: Certain chemicals, such as toluene diisocyanate (TDI), trigger an allergic response that is regulated by specialized white blood cells.

- **Destruction of red blood cells**: When red blood cells are destroyed, the oxygen-carrying capacity of the blood is decreased. Examples: arsine, trinitrotoluene (TNT), and naphthalene (the active ingredient in mothballs).

- **Effects on hemoglobin, the oxygen-carrying part of red blood cells**: Aniline, nitrobenzene, and dinitrobenzene alter the hemoglobin molecule so that it cannot form oxygen. Other chemicals, such as carbon monoxide, do not alter the molecule but combine with it much more easily than oxygen so that the hemoglobin's ability to carry oxygen is severely reduced.

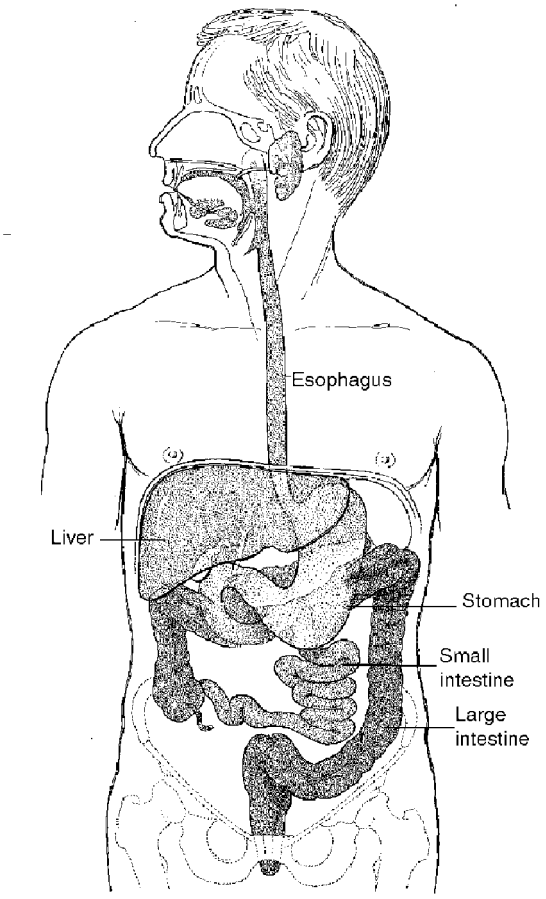
Signs and Symptoms

Signs and symptoms include:

- Weakness
- Fatigue
- Unusually pale skin or mucous membranes
- A resting heart rate of more than 100 beats per minute
- Frequent bleeding from the gums or nose

Gastrointestinal System

The gastrointestinal system consists of the alimentary canal and three accessory organs: the salivary glands, the liver and the pancreas.



The alimentary canal or the digestive tract is a system of organs that extend from the mouth to the anus. It consists of the mouth, pharynx, esophagus, stomach, small intestine, and large intestine. The gastrointestinal tract digests and absorbs food and can also absorb chemicals and other hazardous materials that enter the mouth. Most orally administered chemicals can produce their effects on other body systems only after absorption has occurred from the gastrointestinal tract or, less frequently, from the mouth. The chemicals can also affect the GI system itself.

Most chemicals absorbed in the stomach and the small intestine go to the liver first via the blood supply. The liver metabolizes chemicals and other toxic substances and changes them into a form that can be excreted. This process is called biotransformation. Most biotransformation occurs in the liver, where enzyme systems modify the toxicant. The products of this process are less toxic than the original compound, but in some cases they are more toxic.

Toxic Effects

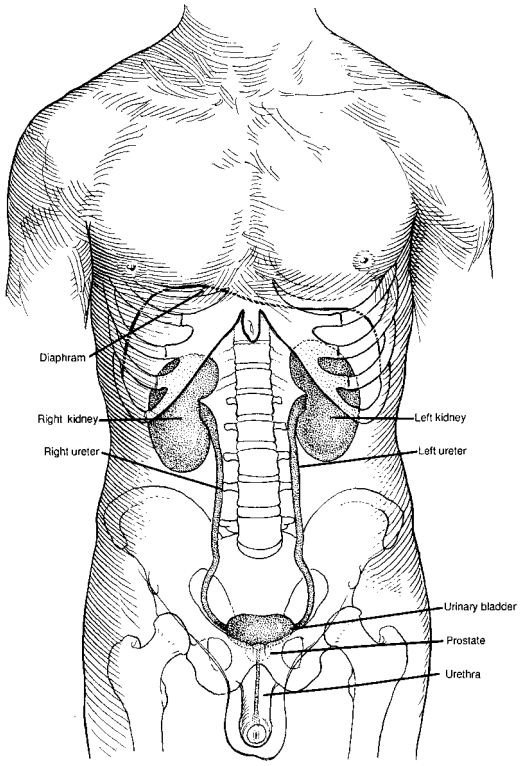
Liver toxicity depends on the specific chemical agent involved in the exposure, the length of the exposure, and the physical condition of the individual. Once again, pre-existing conditions such as liver problems (e.g. cirrhosis or hepatitis) increase susceptibility. A hepatoxin affects the liver's ability to detoxify, or rid itself, of other substances. Diet, hormone activity, and alcohol consumption can also affect biotransformation in the liver.

Examples of toxic effects of hepatoxins include:

- **Cell death** or **necrosis**
- **Cirrhosis**, which is a progressive fibrotic disease of the liver
- **Malignant tumors**

Urinary System

The kidneys and bladder are the primary organs of the urinary system. The kidneys act as filters to remove wastes from the blood. These wastes are excreted as urine. From the kidneys, urine flows to the urinary bladder via ureters. The bladder collects and stores urine, which is eventually discharged from the body through the urethra. The kidneys maintain a balance of water, salt, and pH in the body. They are the body's primary means of excreting metabolic wastes such as urea and uric acid, as well as certain toxic materials. Poorly or non-functioning kidneys may be unable to eliminate toxic substances from the body.



The kidney and bladder are susceptible to toxins for several reasons. Blood flow to them is much higher than to most other organs. As a result, large amounts of circulating toxins can reach the kidneys and the bladder fairly quickly. The kidneys have a high oxygen and nutrient requirement because of this heavy work load. They are affected by any factor (such as shock, hemorrhage, or dehydration) that reduces blood flow. Systemic effects of toxins elsewhere in the body can also indirectly affect kidney function.

Because they adjust the amount of water and other components in the blood and urine, the kidneys are capable of increasing the concentration of a toxic substance. In fact, a non-toxic concentration of a chemical in the blood can suddenly become very toxic in the kidneys. The same is true for the bladder, where the concentration and amount of urine control the amount of toxin in contact with bladder tissue. Dehydration due to lack of fluid intake can cause urine to be more concentrated.

Toxic Effects

Toxic effects include:

- **Renal failure**: Toxins that affect the kidneys are known as nephrotoxins. If these substances, or their metabolites, cause direct damage to the kidneys, the kidneys' ability to filter blood will be partially or totally destroyed. This failure to function is known as renal (kidney) failure. Heavy metals such as mercury, cadmium, arsenic, and lead can cause renal failure.

- **Carcinogenesis**: Many organic compounds such as carbon tetrachloride, chloroform, and the herbicide Paraquat are also examples of nephrotoxins that cause cancer.

Signs and Symptoms

Signs and symptoms include:

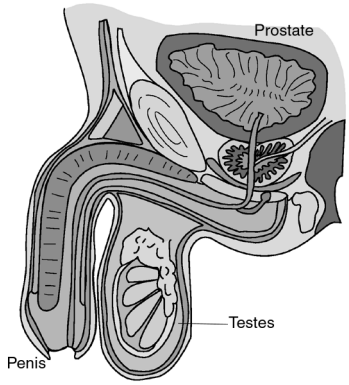
- Change in the volume of urine unrelated to fluid intake, any difficulty or pain during urination, blood in the urine (usually difficult to see with the naked eye)

- Edema, or swelling in the feet or hands that is usually equal on both sides of the body

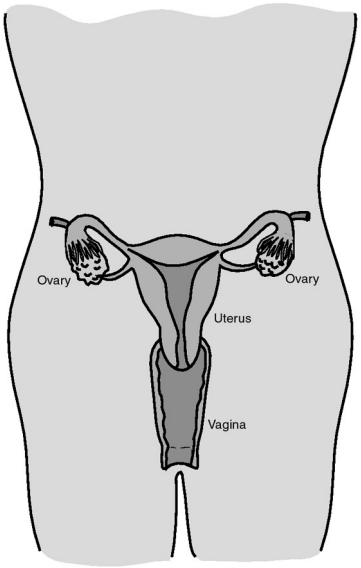
- Flank pain (in the back, just above the hips)

Reproductive System

The reproductive system in males includes testes, accessory glands (prostate), penis, and conducting tubes that lead from the testes to the outside of the body. Specific hormones act on the testes, stimulating them to produce testosterone and sperm. A number of toxicants have been associated with impairment of sperm and testosterone production and may even lead to sterility.



In females, the principal reproductive organs consist of the ovaries and the uterus. Hormone production such as estrogen and the development and maturation of the ovum (egg) are key functions of the ovaries. These functions can be impaired by exposure to hazardous materials. Exposing a fertilized egg (either an embryo or a fetus) to a toxic substance may be harmful.



Certain individuals may be more susceptible to reproductive system toxicants because of their age, nutritional status, or other exposures.

Toxic Effects

Toxic effects include:

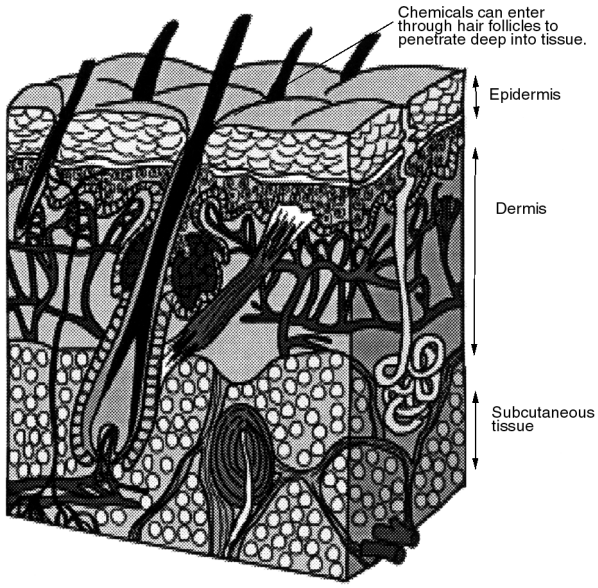
- **Sperm production**: A decrease in sperm production can reduce fertility or even cause sterility. Examples of chemicals that reduce sperm production include dibromochloropropane (DBCP) and ethylene dibromide (EDB).
- **Infertility**: The result of effects on the production of ovum (egg) or the pathway of the ovum
- **Impotence**: Resulting from effects on the parasympathetic nervous system
- **Hormonal changes**: Hormones regulate the male and female reproductive cycles.
- **Premature delivery** or spontaneous abortion
- **Congenital malformations** of developing embryos

Examples of agents that have been associated with reproductive dysfunction in men are ionizing radiation, carbon disulfide, dibromochloropropane (DBCP), ethylene oxide, hexane, and lead.

Examples that have been associated with reproductive dysfunction in women include ionizing radiation, carbon disulfide, methyl mercury, and lead.

Skin

The skin has two layers: the outer layer (epidermis) and the inner layer (dermis). The skin preserves the body's balanced environment in several ways. It protects the body from extremes in the environment. The extensive capillary network and sweat glands are an important part of temperature regulation. Other functions of the skin include the regulation of water balance and the excretion of some water and waste products from the body. It also protects against mechanical and some thermal injury, as well as serving as a barrier against many living organisms.



The skin is less able to protect against toxicants and chemicals. Even when intact, chemicals can travel through the epidermis or enter the body through the hair follicles. In general, fat soluble liquids and solids are more capable of penetrating the skin because of the fat content in underlying tissue. The amount absorbed depends on the amount of time in contact with the skin; the longer the contact, the more will be absorbed. Local skin factors such as temperature and blood flow at the site will also influence the rate of absorption.

Intact skin is normally an excellent barrier to foreign substances; however, the skin can be damaged by trauma, heat, cold, humidity, and previous chemical exposures. If

exposure does occur, the amount of the chemical that is absorbed depends on how much was applied, the concentration, length of contact, and the exposed surface area.

The permeability of skin varies according to the body region. Areas that are rich in hair follicles allow greater absorption. These include scalp, forehead, jaw area, underarm and scrotum/perineal area. Moisture, particularly sweat, increases absorption; so may the presence of other chemicals. Solvents, in particular, can increase permeability. The presence of surfactants, such as soaps and detergents, will increase the absorption of water soluble substances. Also, any breaks in the skin caused by chapping, cuts or abrasions will enhance absorption.

Toxic Effects

There are five types of toxic skin reactions:

- **Irritation**: A substance acts on normal skin at the site of contact and produces a local inflammatory response, known as dermatitis. This is different from an allergic reaction. Dermatitis can result from an acute exposure or repeated contact. Examples of substances causing irritation include trioxides, dichromates, and most solvents.

- **Corrosion**: The result of direct chemical action on skin that results in its disintegration at the site of contact. Ulceration, tissue death, and subsequent scar formation can occur. An example of a corrosive material is chromium.

- **Photosensitization**: Exposure to a chemical followed by exposure to sunlight, with resulting sunburning, skin thickening, or pigment changes. Examples include soaps, detergents and medicines.

- **Sensitization:** An allergic reaction after prolonged or repeated exposure. Potassium dichromate, turpentine, and formaldehyde can cause sensitization.

- **Carcinogenesis**: Cancer of the skin. Any type of skin cell (in the dermis or epidermis) may be transformed from a normal cell to a cancerous one. Causes of skin

cancer include exposure to ultraviolet light, ionizing radiation, arsenic, and polycyclic aromatic hydrocarbons (PAHs).

Signs and Symptoms

Signs and symptoms of toxic skin effects mainly appear on exposed areas of the skin and may include:

- Rash or redness
- Localized swelling
- Peeling
- Skin thickening and the appearance of vesicles (blisters)
- Itching or burning

The Nervous System

The nervous system allows the body to detect and respond to stimuli. The two principal divisions are the central nervous system (CNS), consisting of the brain and spinal cord, and the peripheral nervous system (PNS), consisting of the nerves that link the CNS with the skin, other body organs and muscles.

Toxic effects are partially controlled by predisposing factors such as alcohol consumption, and health conditions that affect the nerves, such as diabetes. The primary concern is nerve cell injury because these cells have little capacity to regenerate. Though normal nerve function sometimes returns, as other nerves begin to compensate for the injury, recovery is slow.

Toxic Effects

Fat soluble chemicals are more likely to affect the nervous system. Many solvents and organic metals can easily reach brain tissue after absorption. Tetraethyl lead is one example. But not all brain cells are affected in the same way since certain areas receive different doses and some cells are more sensitive to toxic exposure.

CNS toxicants may cause subtle effects such as personality changes, or dramatic ones, such as loss of balance. Testing can be done to evaluate the seriousness of the effect. PNS toxicants can interfere with motor function (strength and movement), sensory function (ability to sense touch, vibration or pain), or both. Some of these effects are reversible while others are not.

Like many other body systems, the partially developed nervous system, as in the very young, is much more sensitive to toxins. Low level lead poisoning in children is characterized by central nervous system effects such as hyperactivity and learning disabilities.

In adults, effects on the PNS are seen first.

Signs and Symptoms

Signs and symptoms of toxic effects in the nervous system include:

- Personality changes
- Loss of balance
- Changes in motor function
- Changes in sensory function

Eyes

The eyes are affected by the same chemicals that affect the skin but they are more sensitive. Several types of compounds can burn the eyes by direct contact. Factors that determine the extent of injury include concentration, pH, duration, eye defense mechanisms such as tearing and blinking, and of course, the specific chemical involved.

Toxic Effects

Acid burns such as sulfuric, hydrochloric, hydrofluoric, and tannic acids can cause scarring of the lids and conjunctiva, and can damage other structures of the eyes. Alkali burns from ammonia, sodium hydroxide, and potassium hydroxide may initially appear to be mild, but can later result in ulceration, perforation, or clouding of the cornea or lens.

Lacrimators such as chlorocetophen (tear gas) cause tearing at low concentrations. They are distinguished from other eye irritants such as hydrogen chloride by their ability to cause an instant reaction without damaging tissue. At very high concentrations they can cause chemical burns and destroy the cornea.

Some chemicals reach the eyes and cause damage by way of the blood system. The route of exposure could be inhalation, ingestion, or absorption instead of direct contact. Some examples include naphthalene, carbon disulfide, and methanol.

Ears

Hearing loss can be due to a number of factors, such as trauma, recurrent infections, obstruction by a foreign body, antibiotics, some infections, other medical conditions, as well as advancing age. The primary work-related agent responsible for hearing loss is noise. The ear's response to noise depends on three factors: noise intensity, duration, and the frequency or composition.

Toxic Effects

When a person is subjected to a loud noise in a certain frequency range, hearing may be impaired, resulting in decreased ability to hear low volume noises. Such hearing losses are usually temporary; however, higher intensity noises of prolonged duration can permanently damage hearing.

There is some new evidence that fire fighter exposure to carbon monoxide and hydrogen cyanide can also be responsible for hearing loss. It is essential that you protect all routes of entry and use hearing protection routinely in loud environments. Of course, the first goal is to reduce or eliminate the source of the noise whenever possible.

Activity

Medical Surveillance

Emergency response work takes a direct toll on the health of emergency responders. In 1997, 34 fire fighters died from occupational diseases. Another 72 members were forced to retire as the result of occupational disease. In fact, service separations related to injury and disease represent nearly one in three retirements.

While we have always been aware of fire fighters who die from traumatic injuries at emergency scenes, it is only relatively recently that we have become aware of the number who die as the result of occupational exposures to hazardous materials. This is because the negative health effects of these exposures can be very subtle and can take years, even decades to become apparent. Heart and lung diseases and cancer are a few of the many health conditions now associated with fire fighting and hazardous materials response.

Confronting this health reality means developing programs that will protect you and your fellow fire fighters during emergency response. These include the use of standard response procedures and personal protective equipment including positive pressure self-contained breathing apparatus. It also means going the extra step to carefully monitor your health to detect any effects from hazardous materials exposure.

It's a Good Idea and It's also the Law

The Occupational Safety and Health Administration's final rule (29 CFR1910.120) regarding Hazardous Waste Operations and Emergency Response specifies minimum requirements in a number of areas of hazardous material emergency response. One area covers the provision of a medical surveillance program. Similarly, the Environmental Protection Agency has established equal protection for all employees not covered by OSHA. Hazardous materials team members have a right to medical surveillance. In addition,

the National Fire Protection Association has developed a standard for fire department occupational safety and health programs (NFPA 1500). This standard specifically addresses the need for a comprehensive approach to the health and safety of fire fighters and emergency medical care providers.

A medical surveillance program can help to determine if you can safely perform job duties and use personal protective equipment. It is also designed to detect early changes in body system functions that may have been caused by exposures. Early detection encourages early treatment so that permanent damage does not occur. It is important to remember that medical surveillance programs do *not* take the place of other health and safety strategies or your annual medical exam with your private physician. All of these programs working together help to protect your health.

The Importance of Monitoring Health Status

To effectively track the status of your health, you must have a baseline physical and assessment followed by routinely scheduled evaluations. It is from these snapshots that key information about health changes can be detected. These snapshots are made up of information from a number of different sources. The sources, when taken together, give a detailed portrait of your personal health.

Sources of information include:
- Questionnaire data
- Physical examinations
- Diagnostic medical testing
- Biological monitoring

Questionnaire Data

Questionnaires provide important information regarding your medical, occupational, family, and other personal background. A special emphasis is placed on current symptoms that might be related to hazardous materials exposure.

A key component of the questionnaire is determining risk factors. Risk factors are areas that might predispose you to a negative health effect. For example, someone with cardiac or respiratory disease history might not be able to wear fully encapsulating chemical protective clothing or self-contained breathing apparatus in strenuous situations. Other risk factors include chronic obstructive pulmonary disease (COPD), severe asthma, or previous heart attack. Also, a history of difficulty breathing, heat intolerance, or current obesity may indicate potential problems using personal protective equipment.

In addition to risk factors, questionnaires should also include an area devoted to occupational history. This section looks at current job duties, previous employment and part-time work. This type of information, including non-occupational exposures, (perhaps from hobbies such as car repair) can help to pinpoint areas of potential concern. Previous known exposures to asbestos and solvents such as benzene are other examples.

Physical Examinations

There are a variety of medical examinations that may be appropriate during your participation in a comprehensive medical surveillance program. Some of these examinations are routine and others are specific to known or possible exposures. Knowing the different types can help to ensure that you participate successfully.

Pre-placement Exams

A pre-placement exam is given at the time of hiring or change in job duties. It is an important opportunity to gain baseline or initial data for use in future comparison. It allows the physician to determine if you can safely wear protective equipment while working in a hazardous environment. Pertinent history includes allergies, illnesses, risk factors, dietary and exercise habits, as well as an occupational history.

Minimal items included in the comprehensive physical examination include:

- Physical evaluation
- Body composition
- Laboratory tests
- Vision tests
- Hearing evaluation
- Spirometry
- EKG
- Cancer screening
- Immunizations and infectious disease screening

These and other tests are described in detail in Appendix C.

Periodic Medical Examination

It is strongly recommended that hazardous materials technicians receive an annual medical review or interval examination. This new medical data is compared to the baseline in order to detect any changes in body systems. These changes can be the basis for further testing or starting medical treatment if necessary. Test results can also provide evidence for changes in personal protective equipment or work practices. These examinations can be performed more frequently if necessary, based on special hazards, exposures, symptoms, or your age or health profile. Any exposures during the interval since the last exam should be carefully reviewed.

You might also have a targeted examination focusing on organs most likely affected by exposures. Other medical testing may be based on exposure information, medical history and the results of the physical exam. For example, blood tests that reflect liver function may be performed if a responder has been exposed to large amounts of petroleum-based solvents.

Acute Medical Care

There is always a chance that hazmat technicians will require medical attention as a result of operations at the scene of an emergency. Team members may become injured or ill from exposures or heat stress. It is essential that provisions be made for emergency medical care at the site. Because of the nature of the work, Advanced Life

Support should be available to treat and transport team members requiring attention.

As part of your pre-planning process, identify hospitals in your area that are equipped to handle chemical and toxicological emergencies. These facilities may have specially trained providers and equipment that could make the difference in an emergency.

Activity

Post-Exposure Monitoring

Post-exposure monitoring may be necessary even if members are not experiencing symptoms. Testing may also be required even after medical treatment has been completed. In some cases, depending on the type of exposure, specific tests can be administered to quantify the exposure. These tests can serve as the basis for determining whether or not additional medical treatment is necessary.

It is very important that all confirmed or suspected exposures be carefully documented in written form. These records are very useful during the annual medical review and can also be used as claims evidence in applicable workers compensation cases.

These evaluations are designed to assist in the early identification of illness or injury that may be related to the adverse effect of a work site exposure or the working environment. In addition, any employer having workers with occupational exposures to infectious diseases is required to establish a written exposure control plan designed to eliminate or minimize exposures and to handle them properly when they occur.

A typical follow-up procedure for a common exposure, asbestos, is detailed below:

- Upon confirmation of an exposure to asbestos, the following baseline evaluations should be completed if

documentation does not exist that these evaluations were done within the previous 12 months or other identified schedule:

- Basic physical evaluation and examination
- Pulmonary function tests (FVC FEV1.0)
- Chest X-ray, 14"x 17" post./ant.

- Members known to have been exposed are subject to the following schedule for continued testing:

Years since first exposure to hazardous materials	Age 15 to 35	Age 35 to 45	Age 45+
0 to 10 years	Every 5 years	Every 5 years	Every 5 years
10+ years	Every 5 years	Every 2 years	Every 1 year

- In addition to the above evaluations, the OSHA Asbestos Standard Periodic Medical Questionnaire shall be completed.

- This information shall be reviewed and evaluated by the physician to ensure that appropriate medical follow-up is identified and communicated to personnel. Information concerning the occupational risks of exposure to asbestos should be provided to applicants during initial training and on a yearly basis to incumbents. Training and education should describe the nature of asbestos, proper respiratory protection and use of respirators, and procedures for minimizing the risk of exposure to asbestos.

Exit Examination

This examination is performed when you leave your department or transfer to work that does not involve continued exposure to hazardous materials. The purpose of an exit exam is to establish the state of a member's health at the conclusion of a specific job assignment. The components of the exam are similar to those of the periodic exam.

Physician Qualifications

The physician conducting surveillance exams must be well acquainted with the fire/rescue service and the special needs of hazardous materials emergency responders. Physicians trained in occupational medicine or toxicology are ideally suited to conduct surveillance programs. It is essential that all physicians be familiar with OSHA/EPA requirements and NFPA standards as well as common work practices. Physicians must also be aware of and follow applicable confidentiality and reporting requirements.

Record Keeping

Maintenance and access to your medical records must be in accordance with OSHA regulations. The procedures set forth in NFPA 1500 should also be included in department policies. If you are exposed, OSHA regulations require that your medical records be maintained for 30 years after you leave employment.

The results of medical tests must be made available to you on request. The employer is only informed about limitations in your work duties, *not* specific information about medical conditions. The cornerstone of a professional, successful medical surveillance program is confidentiality. Without the trust afforded by confidentiality, the program will fail.

In addition, medical surveillance record keeping must follow these guidelines: The employer must retain your name and social security number, the physician's written opinion, any employee medical complaint related to exposures, and a copy of information provided to the examining physician by the employer regarding employee exposures.

Record keeping and reporting of occupational injuries and illnesses must be performed yearly. This function helps reveal injury trends related to equipment and procedures. Finally, you must remember the importance of routinely documenting work-related exposures. You must retain your own copy of these exposure records. Some local unions and state associations also keep exposure records. This

documentation serves as the basis for needed changes and improvements in emergency operations. Documentation also plays a crucial role in diagnosis, treatment and coverage for some medical conditions.

Annual Program Review

Just like any other program, the medical surveillance component should undergo review to ensure that it is effective. This review, which should occur annually at a minimum, can also help to identify injury trends and special health effects. Review elements should include:

- Assessments of injuries and illnesses to determine the cause. This process allows you to modify health and safety procedures when necessary.

- A review of medical testing for exposures and environmental monitoring to ensure that they are useful

- An examination of emergency response capabilities and treatment procedures and an updated list of emergency contacts and facilities. Through the on-going planning process, response capabilities should address new hazards and possible exposure.

- A careful analysis of group data to detect trends that may not be apparent through individual results. From these findings, deficiencies in such areas as training or personal protective equipment can be corrected.

- A review of hazardous materials responses, medical records, and exposure reports to ensure that team members are receiving proper follow-up care

- A review of confidentiality procedures and safeguards to ensure that member privacy is protected. An audit of reporting procedures can ensure that only information on work status and restrictions is communicated to management. This element builds trust in the medical surveillance system and will encourage members to participate fully and completely in the process.

Activity

A thorough medical surveillance program is a central part of an effective emergency response. It enhances planning and serves as a guide for improvements in training, equipment and procedures. Most importantly, it safeguards the health of responders by creating a system for consistent and thorough review of exposures and their effects.

Elements of a Proactive Health Strategy

Every emergency responder should achieve—and maintain—extremely good health. Good health can help you enjoy a full life while offsetting the demands of emergency response. Even routine emergency events (as well as how you prepare for them) can be highly stressful. This stress can result in disease processes that have both physical and mental dimensions.

Negative health effects such as serious accidents or health problems such as heart disease and cancer are essentially emergency incidents for our bodies. Our goal is to avoid these emergencies whenever possible and to provide adequate resources to deal with them if they occur. We do this in the same way we deal with any emergency—by preplanning and providing adequate resources to overcome the incident. As with emergency incidents, the more care we give to preparation and planning for our health, the move effectively we can deal with a health event if it does occur.

The goal then, is to remain as healthy as possible through a comprehensive personal program that takes into account our physical, emotional and medical needs. If you pay daily attention to these needs, you will reap significant benefits—not only in emergency performance, but also in your ability to enjoy life. The benefits of a sustained commitment to well-rounded personal health include:

- Less risk of death or injury or a disabling disease
- Improved physical performance
- Decreased levels of stress, tension and anxiety
- Enhanced ability to rest and sleep
- Better ability to bounce back from strenuous events

Some key components of a proactive health strategy are: medical review, fitness, diet, and stress management.

Medical Review

Emergency responders are exposed to a complex and dangerous work environment that includes exposure to a wide range of toxins and infectious materials. The work environment also includes a high degree of on-going stress that can cause a variety of diseases. Because of these factors, you must participate in a comprehensive annual medical review program designed to detect and treat adverse medical conditions. Such a program is vital to ensuring good health. (Many of these components are also included in the Medical Surveillance section).

A comprehensive medical examination includes:

- Physical evaluation
- Body composition
- Laboratory tests
- Vision tests
- Hearing evaluation
- Spirometry
- EKG
- Cancer screening
- Immunizations and infectious disease screening

An annual medical review helps ensure that emergency responders are well informed about their physical health. A life-long, consistent comparison of essential health data can help detect changes that require follow-up to eliminate the possibility of disease. It is a critical element in a proactive health strategy.

Personal Fitness

Physical fitness is critical to your overall health and your ability to perform safely and effectively as an emergency responder. Higher levels of aerobic fitness, muscular endurance, and muscular strength are key assets in the emergency response profession. All members participating in fitness programs should be medically cleared prior to doing so. This clearance can establish a health baseline and rule out any existing medical issues that might preclude participating in a fitness program.

Aerobic Capacity

Aerobic capacity is an integral part of a fitness program. Improved aerobic capacity leads to better cardiovascular fitness and keeps blood pressure, weight, and body chemistry in the normal ranges. There is little debate that a high aerobic capacity is a prime goal for fire fighters and other emergency responders.

Flexibility

Because emergency response work is physically demanding and often requires intense physical labor in restricted areas, the majority of injuries are sprains and strains. In addition, many fire fighters are forced into retirement each year because of disabling back injuries. An important part of injury prevention is a flexibility program that creates full range of movement for joints and muscles.

Muscular Strength and Endurance

Muscular endurance is defined as the ability of a muscle group to perform work over a period of time sufficient to cause muscle fatigue. Fire fighting and emergency response work frequently requires maximum exertion. Maintaining an appropriate level of muscular strength not only allows you to perform your work efficiently, it establishes a reserve that can prevent sprains and strains. A routine strength training component is a standard part of responder fitness.

Promoting Good Health Through Positive Behaviors

Wellness is critically linked to your personal behavior in a number of key areas. The decisions you make and the ways in which you choose to manage stress are all linked to your overall health. Behavioral health encompasses many areas, including:

Smoking: The use of tobacco in any form is associated with a wide range of negative health effects including heart disease and cancer. Effective programs to stop the use of tobacco are essential.

Substance abuse: The abuse of alcohol is by far the largest concern. An effective program to educate members and new hires about the problems associated with alcohol and drug abuse is an important part of health promotion. In addition, treatment at reasonable cost should be made available for those who require it.

Stress management: To manage stress effectively you must first be aware that you are subject to a variety of stressors. Among these are typical job stress, critical incident stress, stress from financial and legal concerns, family relations, and stress from issues such as infectious disease exposure. To manage stress, you need to recognize common reactions such as loss of appetite, trouble sleeping, and anger. Every responder needs to make full use of programs to combat stress. Such programs include professional counseling, peer support, and education. The value of regular exercise as a tool to relieve stress should also be emphasized.

Nutrition

Proper nutrition is a key part of proactive health maintenance. The basic fuel necessary to respond safely and effectively to any emergency is found in our daily diet. The higher the quality of the fuel you consume, the more effective and efficient we can be. High quality nutrition improves the quality of life and the performance of emergency responders. Some of the positive aspects of a good diet are

increased energy, shortened recovery time, and improved resistance to diseases.

Two of the major risks of emergency response work—cancer and heart disease—can be lessened through good nutrition. A diet low in total fats, saturated fats, cholesterol and salt, and high in fruits, vegetables, and fibers is a nutritional game plan that may help offset these disease processes.

Following are some basic daily guidelines for a healthy diet:

- Carbohydrates: 50% to 70%
- Proteins: 15% to 30% (A typical serving of protein for an adult male would be the size of the palm of the hand and about the thickness of the hand.)
- Fats: No more than 30%
- Eat five or more servings of fruits and vegetables
- Reduce the amount of cholesterol, salt, and fats, particularly saturated fat
- Replace high fat meats with lean cuts
- Increase fiber intake
- Drink plenty of non-caffeinated and alcohol free beverages. Signs of dehydration include dark urine, a small volume of urine, and headaches. Remaining adequately hydrated is essential for emergency response personnel.

Health and Safety Response Principles

Always Have a Plan

In many cases, hazardous materials events involve patients who are exposed or injured. Operating safely in such a dynamic environment requires that you maintain your composure and only take those actions that are reasonable and appropriate. One of the best ways to ensure that you operate safely is to have a plan and follow it.

- **Analyze the Problem**. Using your size-up and hazardous materials skills, determine exactly what is occurring. Is the environment dynamic? Is there an immediate rescue problem? Do you have resources and equipment to rescue a viable patient? What are the full range of hazards present? What will happen if you take no action at all?

- **Plan the Response**. Based on your analysis, decide which actions are appropriate. Ensure that the necessary resources are present or en route. Plan your steps carefully, keeping safety as a top priority. Use the risk/benefit scenario to gauge your level of hazard and exposure.

- **Implement Your Plan**. Take the actions you have determined to be appropriate based on your department's procedures. Operate as a team, and ensure that you have back-up. Minimize exposure to the hazardous substance and keep your time and actions in the Hot Zone to a minimum. If you are contaminated, ensure that you are properly decontaminated and assessed after you leave the Hot Zone.

- **Evaluate Progress and Adjust as Necessary**. Observe your progress and remain aware of your effectiveness and the presence of new or additional hazards. Adjust your plan if necessary to reflect changing conditions. Think ahead and always keep a margin of safety for you and your crew members.

Stay Alert to Changes

Planning is an essential component to a safe response. It is important to remember that these incidents are very dynamic. Based on the type and amount of materials involved and other factors such as the location, time of day, and the weather conditions, the incident can change rapidly. Whenever possible, create contingency plans during the planning process that take into account some of these dynamic variables.

Often it will be very difficult to identify all the possibilities. Changes in wind direction and air temperature, settling of contents in a container, and changes in smoke color or fire intensity are just some of the indications that the incident may be escalating or creating new dangers for responders. In many cases, the longer you work at an incident the more likely you are to be lulled into a false sense of safety. The challenge for professional responders is to stay alert at every stage of the event, all the way through wrap-up and termination.

Take Only Appropriate Actions

Your priority list:

- Safety of emergency responders
- Safety of civilians
- Preservation of property
- Preservation of the environment

The actions that we take at the scene of an emergency should be in line with our established health and safety priorities. Our highest priority is to save a savable life. In this scenario, you could justifiably be placed at significant risk. For those incidents where *no* life threat exists, you should be placed at low or minimal risk.

Making sure that our actions are appropriate means establishing a realistic plan based on what is occurring, what we expect to achieve, and our available resources. In addition, you must be must be fully aware of :

- The materials involved
- Weather conditions
- Accessibility to the incident
- Ignition sources
- Containment systems (piping, dikes, tanks)
- Damage to storage containers
- Vulnerable populations

Making wise response decisions based on a realistic appraisal of what is happening— and what is *likely* to happen— is the best way to ensure the safety of team members.

Take All Steps to Protect Against Exposure

Enter the Hot Zone or contaminated area *only* if there is some clear benefit from doing so, such as lives that can be saved.

Before entering the Hot Zone, take the following precautions:

- Review and plan control actions
- Work upwind and uphill and avoid contact with product
- Use remote shutdown sources, tools, and equipment to help reduce or avoid contamination
- Select and use the proper type and level of personal protective equipment

Good decontamination procedures offer additional safeguards that remove contaminants from PPE. The decontamination process should allow team members to exit the Warm Zone with the knowledge that all of the contaminants have been removed.

Site security and clear designation of zones and work areas can lessen the opportunity for exposure by eliminating the likelihood that contaminants will spread outside the Warm Zone.

Pre- and post-entry assessments and the use of personal hygiene showers are an additional safeguard that helps team members leave the incident area free of contaminants.

Avoid Secondary Contamination

Each technician must work together to closely monitor the flow of potentially contaminated personnel, patients, tools and equipment. The strict use of control zones and implementation of safe work practices and decontamination procedures can reduce the opportunity for secondary contamination.

Continuously monitoring members and equipment reduces the chance of contaminants spreading outside the Warm Zone. In addition, take all possible steps to ensure that patients are properly decontaminated prior to treatment and transport. Often, simply removing the patient's clothing can remove up to 75% of the hazardous material. Taking the time to remove contaminants ensures that EMS personnel and hospital staff will not be unnecessarily exposed. One of your chief responsibilities is to strictly limit the opportunity for contamination outside of the incident area.

Keep Your Health and Safety a Top Priority

Remaining healthy and safe in the hazardous materials emergency response setting means having a proactive plan. Much like emergency response preparation, it requires learning in advance what the risks are and determining the special problems you may encounter.

Learn the personal health program components that make a difference. Medical reviews, exercise, diet, and rest create a healthy responder with a strong reserve capacity.

Taking a planning approach to incident safety helps you take the "guess" out of the work and focus instead on the safest, most efficient way to accomplish the tasks. A good plan includes analyzing the hazard, having sufficient

resources, and creating a comprehensive site safety assessment.

Finally, examine the risks and the potential benefits and take *only* those actions that are wise, prudent and safe.

Activity

Elements of a Proactive Safety Strategy

The safest possible emergency scene is one where careful observation and planning results in a strategy that takes into account all of the known hazards. Unnecessary guesswork can create an incident scene where responders take the wrong actions with catastrophic results. Having a proactive safety strategy helps plan for the emergency in advance so you have as much information as possible when you go to work.

Thorough Planning

Effective pre-planning is the keystone of a safe response. This is particularly true where hazardous materials emergencies are concerned. Thoroughly pre-plan high hazard occupancies; those that frequently have problems, or areas where an event could be catastrophic should be thoroughly planned in advance. Gaining key information about the processes and products used at these facilities can make initial emergency actions more safe and effective. Good planning means that you will know essential information such as building construction, in-place protection procedures, and professionals who can be contacted both on and off site.

Many transportation corridors are sites of repeated hazardous materials incidents involving roll-overs and fires. These target transportation hazards can be pre-planned to determine the safest and most effective way to handle a spill if it occurs. Be sure to identify critical items such as water supply and storm drainage. In addition, you can identify local and state resources who can respond during an incident. Knowing these contacts in advance ensures a safer response.

Adequate Resources

While you can never know exactly when or where an incident will occur, you can identify the available resources in advance. In addition to traditional fire and rescue companies, specialized department resources such as technical rescue and hazardous materials teams should be noted. The availability of mutual aid departments is also an important resource. Often, these mutual aid sources can assist directly in an emergency or provide standby service.

In hazardous materials emergency response, identifying resources in advance is particularly crucial. Industry experts, chemists, and spill control teams as well as local and state governmental agencies, can provide important help while the emergency is under way. To make the most of these resources, identify them in advance and build a working relationship before an emergency occurs.

Other resources include federal assistance such as the:

- Coast Guard
- Environmental Protection Agency
- Occupational Health and Safety Administration

Effective, comprehensive development of resources before the incident means a safer coordinated response.

Hazard Analysis and Risk Assessment

Once target areas have been identified, you can determine the likelihood that an event will occur at a particular occupancy. When visiting a petroleum tank farm, for example, you should learn every aspect about large storage tanks, large diameter pipeline delivery systems, and bulk delivery by tanker trucks. This process allows you to determine not only the full range of hazards, but also the emergencies that are most likely to occur. Learn about what goes on at a particular facility by reviewing information such as permit applications, inspection reports, Material Safety Data Sheets, and site drawings. By filling in these important blanks ahead of time, you reduce the unknowns and create a safer emergency response when you arrive on the scene.

Site-Specific Safety and Health Plan

Before beginning operations at a hazardous materials incident, develop a basic safety and health plan that takes into account the special concerns and risks associated with that incident. Doing this ensures that, at each incident, you take the time to determine the incident characteristics that pose the greatest risk. For example, have you taken the time to evaluate the secondary hazards of all materials involved? Have you clearly identified the hazards associated with each of the tasks that may be performed? Observing the incident scene from a safety plan point of view will help to ensure a low-risk response. Many of the items included in a safety and health plan review can be completed during preplanning activities at target hazard locations.

- **Safety and health risk** or hazard analysis for each site task and operation in the work plan. For example, if a drum filled with a flammable and toxic substance is uprighted and moved, are controls and tools in place to safely move the container and avoid creating sparks?

- **Adequacy of personal protective equipment**. Research for chemical hazards to ensure that the protective clothing you choose meets the needs of the wearer and the tasks that will be performed.

- **Environmental and air monitoring**. A primary component of the safety plan is the reconnaissance and characterization effort. The use of appropriate instrumentation can help determine exactly what hazards are present, and in what concentrations.

- **Decontamination procedures**. Review and verify proper decontamination procedures during the research process. These procedures outline the steps that must be taken to ensure that team members are free of all contaminants when they exit the Hot Zone.

- **Emergency action plan.** Just because you have responded to an emergency does not mean that an emergency can not occur once you have begun operating. Protective equipment failures and sudden product

releases can necessitate quick action on the part of the emergency response team. The plan must identify these likely scenarios and how the team will respond if an emergency occurs. These items include emergency exit routes, decontamination procedures, and the provision of emergency care.

- **Confined space operations.** If the emergency event involves confined spaces, then appropriate procedures, equipment, and personnel must be in place to ensure a safe entry, if one is deemed appropriate.

- **Pre-entry briefing.** Prior to any crew entering the Warm or Hot Zone, or performing tasks where personal protective equipment is required, they should receive a briefing by an operations officer who defines the tasks, equipment required, special conditions or concerns, and relevant emergency procedures.

The site safety plan should also include information on site security and control, general evacuation routes and procedures, personnel roles, lines of authority, and communication. With this information, everyone knows who is in charge of the incident and exactly what to do if an emergency occurs during operations.

Application Exercises

Application Exercise

You will need:

- Five drums or other containers that could be used for hazardous materials
- Descriptions of five very short incident scenarios incorporating hazardous materials common in your local area
  - Do not specifically identify the hazardous materials in the scenarios
  - Use at least three hazard classes
  - Use different levels of toxicities for each chemical
  - Incorporate victims, vulnerable areas, etc.
- UN ID numbers for the hazardous materials used in your scenarios
- North American Emergency Response Guidebooks
- Additional reference books and other resource material normally used within the department
- Twenty-five copies of the questions on the following page

Preparation:

This exercise is intended to help students understand the effects of hazardous materials and take appropriate actions to protect themselves. Set up the drums or containers at various places around the training facility. Tape one scenario and the related UN ID number to each container. (Make sure the containers are appropriate for the chemical.)

Divide the class into five groups. Give each group a North American Emergency Response Guidebook, and any other reference materials they would have access to in their department, and five copies of the questions on the following page. Do not allow them to use their Student Texts. Assign one group to each container. Tell the groups to read the scenario, identify the chemical using the UN number and the Guidebook, and answer the questions on the following page. After about 30 minutes, rotate groups to different containers. Continue the rotation until all groups have had the opportunity to work through each scenario. Reconvene the class and discuss each group's responses to the questions.

Application Exercise

Read the scenario attached to the container and identify the chemical. Using any other resources to which you would normally have access, research the chemical and answer the following questions.

1. From what you know about the hazardous material and the situation, how would you assess the risks and benefits of taking offensive action in this scenario?

Material Involved	Risk	Benefit	Assessment (Action taken)

2. What is the DOT hazard class for this material?

3. What are the health effects of this material, both acute and chronic?

4. Has the victim(s) been exposed, contaminated, or both?

5. What signs and symptoms should you look for in the victim(s)?

6. Which body system will suffer the most serious effects?

7. What action would you take if you were exposed to this material?

Action Statement

Action Statement

You have just completed the third module of the Hazardous Materials Technician course. The topics included:

- Assessment of the risks and benefits of taking action in a hazardous materials incident
- Categories of hazardous materials and their health effects
- Terms related to hazardous materials
- Toxicities of specific classes of hazardous materials
- Toxic effects in specific organ systems
- Elements of a proactive health strategy
- Health and safety response principles
- Elements of a proactive safety strategy

Knowing how you respond to emergencies in your first due areas, would you change your actions or habits based on the information covered in this module? Listed below are some suggested actions. Some you may already do, and others may not fit your work environment. If there are actions you have not done in the past, do you think you will begin doing them as a result of this training?

As a result of this training, I will:

1. More carefully assess the risks and benefits of taking action in a hazardous materials incident
2. Take greater measures to protect myself from the toxic effects of specific classes of hazardous materials
3. During an incident, look for signs and symptoms in the public and fellow responders that could indicate possible exposures to hazardous materials
4. Discuss the specific elements of my medical surveillance plan with an occupational health physician
5. Promote my own well-being through more exercise and healthier personal habits
6. Conduct more and more thorough pre-incident plans
7. (Create my own action statement)

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