Basic Life Support and Hazardous Materials Response

BLSHMR-Student Manual

1st Edition, 1st Printing-June 1995

Homeland
Security

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U.S. DEPARTMENT OF HOMELAND SECURITY

PREPAREDNESS DIRECTORATE

UNITED STATES FIRE ADMINISTRATION

NATIONAL FIRE ACADEMY

FOREWORD

The U.S. Fire Administration (USFA), an important component of the Department of Homeland Security (DHS) Preparedness Directorate, serves the leadership of this Nation as the DHS's fire protection and emergency response expert. The USFA is located at the National Emergency Training Center (NETC) in Emmitsburg, Maryland, and includes the National Fire Academy (NFA), National Fire Data Center (NFDC), National Fire Programs (NFP), and the National Preparedness Network (PREPnet). The USFA also provides oversight and management of the Noble Training Center in Anniston, Alabama. The mission of the USFA is to save lives and reduce economic losses due to fire and related emergencies through training, research, data collection and analysis, public education, and coordination with other Federal agencies and fire protection and emergency service personnel.

The USFA's National Fire Academy offers a diverse course delivery system, combining resident courses, off-campus deliveries in cooperation with State training organizations, weekend instruction, and online courses. The USFA maintains a blended learning approach to its course selections and course development. Resident courses are delivered at both the Emmitsburg campus and its Noble facility. Off-campus courses are delivered in cooperation with State and local fire training organizations to ensure this Nation's firefighters are prepared for the hazards they face.

A great deal of interdisciplinary training already is taking place in the area of emergency medical services response to hazardous materials incidents. The need continues to grow as the number of hazardous materials incidents increases regularly.

There is a critical need for this training. Often, needless injuries and harmful cascading effects occur because emergency medical technicians and paramedics involved in hazardous materials incidents fail to recognize, do not sufficiently evaluate, or do not deal safely with the associated risks.

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SCOPE OF THE COURSE

This new two-day course, *Basic Life Support and Hazardous Materials Response*, will emphasize critical concerns for emergency medical responders at hazardous materials incidents. Elements of this course include safety issues for emergency medical service-hazardous materials response personnel; managing contaminated victims requiring emergency medical assistance; decontamination and treatment procedures of a basic life-support nature; and transportation and receiving facilities. The thrust of the course is to stress the toxicological aspects associated with responding to hazardous materials incidents.

COURSE GOAL

This course will assist the participant in understanding and complying with federal regulations and national recommendations concerning emergency medical response to hazardous materials incidents.

TARGET AUDIENCE

The course targets fire and emergency medical personnel who have a responsibility for managing basic life support (operations-level) emergency medical care at hazardous materials incidents.

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UNIT 1: INTRODUCTION

OBJECTIVES

The students will be able to:

1. *Provide the instructor information on themselves by completing a nongraded training and experience inventory.*

2. *After viewing a tape of an actual incident, and working alone, identify potential problems and safety concerns relative to both the responders and the potential victims.*

Training and Experience Inventory

Directions

Take a few minutes to answer the following questions as accurately as possible. The answers will help the instructor develop a profile of the class in order to more closely match the course materials to your needs.

1. Would you, by yourself, be able to use the Department of Transportation's *Emergency Response Guidebook*?

    a. To identify a product? [ ] yes [ ] no [ ] not sure

    b. To identify appropriate protective clothing for responders at a haz mat scene? [ ] yes [ ] no [ ] not sure

    c. To identify suggested treatment for victims at a haz mat scene? [ ] yes [ ] no [ ] not sure

    d. To determine isolation and protective action distances at a haz mat scene? [ ] yes [ ] no [ ] not sure

2. Is there a current *Emergency Response Guidebook* on your apparatus? [ ] yes [ ] no [ ] not sure

3. Do you know the exact location of the closest Poison Control Center for your area? [ ] yes [ ] no [ ] not sure

4. Do you know how to contact it? [ ] yes [ ] no [ ] not sure

5. To which level (Awareness, Operations, or Technician) are you trained?
    - [ ] Awareness
    - [ ] Operations
    - [ ] Technician
    - [ ] not sure

6. To which group do you belong?
    - [ ] fire service
    - [ ] emergency medical service
    - [ ] combination
    - [ ] hospital or clinic staff
    - [ ] private sector:_______________
    - [ ] other:______________________

7. What is your level of training?

[ ] first responder
[ ] BLS
[ ] ALS
[ ] other:______________________

8. How many emergency medical responses have you been on in the past month?

[ ] 1 to 5
[ ] 6 to 10
[ ] 10 to 20
[ ] 30 to 40
[ ] 41 or more

9. How many of these have been related to hazardous materials?

[ ] 3/4 or more
[ ] 1/2 to 3/4
[ ] 1/4 to 1/2
[ ] less than 1/4

10. To how many automobile collisions have you responded in the past month?

[ ] 1 to 5
[ ] 6 to 10
[ ] 10 to 20
[ ] 30 to 40
[ ] 41 or more

Activity 1.1

Incident Emergency Medical Concerns

Purpose

To identify and describe various aspects of potential emergency medical involvement in an incident.

Directions

1. You will watch a brief video of an incident. After viewing the video, work by yourself to complete the following worksheet. You will have about 10 minutes to do so.

2. **Briefly** identify the problem(s) you would anticipate as an emergency medical responder arriving at this incident.

3. State your concerns relative to the safety of the emergency responders and to the safety of the potential victim(s).

Problem Identification

Safety of the Emergency Responders

Safety of the Victim(s)

UNIT 2: HAZARDOUS MATERIALS OVERVIEW

OBJECTIVES

The students will be able to:

1. *Given a list of alternatives and working individually, identify*
    a. *Three hazardous materials definitions.*
    b. *Three clues that indicate the presence of hazardous materials.*
    c. *Four mechanisms of harm.*
    d. *Five Department of Transportation (DOT) hazardous materials classifications.*
    e. *The levels of protective clothing most appropriate for EMS responders in a hazardous environment.*
2. *Differentiate between direct and cross contamination and wet and dry decontamination.*
3. *Explain the eight common decontamination mechanisms.*
4. *Explain the concept of "work mission duration."*
5. *Given a hazardous substance with its DOT identification number, and working in small groups, identify the mechanisms of harm and describe the types of potential injury from that product.*
6. *Given a scenario of an incident, and working in small groups, identify the permissible levels of medical response and suitable personal protective equipment (PPE) based on recommended levels of training.*

Activity 2.1

Interpreting Clues

Purpose

To name the various clues that can be used to identify hazardous materials incidents or situations.

Directions

As each slide is projected, describe the clues you can use to help determine the hazard involved.

Slide 1 - Dumpster

Slide 2 - Overturned tanker

Slide 3 - Gas production facility

Slide 4 - Hardware store

Slide 5 - Abandoned building

Slide 6 - Automobile collision

Slide 7 - Farm

Slide 8 - Garage/Storage area

Slide 9 - Multiple-tenant storage area

Slide 10 - Abandoned building with hazardous materials graffiti

Activity 2.2

Identifying Mechanisms of Harm

Purpose

To identify the various mechanisms of harm that can be found in hazardous materials incidents.

Directions

As each slide is projected, describe the mechanisms of harm associated with the situation.

Slide 1 - Public community pool

Slide 2 - Natural gas pipeline rupture with fire

Slide 3 - Medical laboratory

Slide 4 - Crash of a cargo plane

Slide 5 - Abandoned propane tank

Slide 6 - Ice rink

Slide 7 - Truck collision with extrication

Activity 2.3

Mechanism of Harm

Purpose

To determine which body system can be injured by each mechanism of harm.

Directions

1. Using the matrix below, indicate for each of the eight bodily systems those mechanisms of harm that could affect it.

2. Indicate as appropriate if you think the conditions could be acute (A) or chronic (C) by placing an A or C (or both) in the box. Acute here implies a prehospital treatment and chronic means occurring over several hours at a minimum.

	Thermal	Etiological	Asphyxiant	Mechanical	Chemical	Psycho-logical	Radio-logical
Neurological							
Respiratory							
Circulatory							
Reproductive							
Musculoskeletal							
Digestive							
Skin							
Renal							

Activity 2.4

Determining Levels of Involvement

Purpose

To help you identify appropriate training and equipment needs while operating in different zones of a hazardous materials incident.

Directions

Using the matrix below, you will decide two things:

1. Are personnel trained sufficiently at each of the three levels to operate in each of the three zones? When you decide "yes" or "no," place a Y or an N in the left half of each box. If you are unsure, place a "?."

2. Whenever you decide that the personnel are trained sufficiently to operate in a zone, select the level of personal protective equipment (A, B, C, or D) needed to operate in that zone. Place an A, B, C, or D in the lower half of each box. If you are unsure, place a "?".

Correlation of Training, Zone Operation, and PPE

	Awareness	Operations	Technician
Cold Zone (Support zone)			
Warm Zone (Contamination reduction zone)			
Hot Zone (Exclusion zone)			

THE HAZARDOUS MATERIALS PROBLEM

Chemicals are everywhere. Their numbers increase daily and their interactions can be frightening. There is practically no jurisdiction in the nation whose emergency services staffs today escape exposure to the chemical problem. Even the most remote areas may have large agricultural concerns that use pesticides and fertilizers on a large scale. As the human race evolves, it seems to become increasingly dependent on the use of chemicals, not only for luxury items but for the basic necessities of life, such as drinking water.

This appetite for chemicals is fueled by many factors, but these are only academic to the emergency responder. The mere fact that chemicals are being used on a widespread basis, coupled with the mission statement of most emergency response agencies, makes it imperative that we prepare for the inevitable chemical emergency.

This course is just one small part of preparing for hazardous materials emergencies. Several generalizations are made about the students in this course. All should be emergency responders or other emergency medical personnel with responsibilities that may include providing medical support at hazardous materials incidents. Though it is hoped that students already will have received operational-level training as defined by NFPA 472, students with a lower level of hazardous materials competencies will benefit from the course.

Experience with hazardous materials disasters has resulted in many lessons being learned and applied in emergency response to chemical emergencies. One of the most important is that there must be an appropriate response to an emergency involving chemicals. There are many case histories that point out the often tragic results of a botched response. This is not always the fault of the persons who responded, but may indicate a lack of training.

The 1980s saw much legislation enacted to address the problem of emergency response to hazardous materials incidents. A great deal of this legislation dealt with training, practices, and procedures for responding to such incidents. The federal government's role in chemical response has increased greatly; this has led to increased funding and the proliferation of training programs.

HAZARDOUS MATERIALS DEFINITIONS

Key federal agencies also have coined their own definitions for what constitutes a hazardous material. There are many such definitions, but the most widely used are listed below. These definitions are not intended to confuse, even though they sometimes do. They are designed to delineate areas of legal responsibility and to categorize substances according to planning and regulatory needs. Notice the similarities and the differences in the more commonly used definitions.

Hazardous Material (Department of Transportation)

Any substance or material in a quantity or form that poses an unreasonable risk to health, safety, or property when **transported** in commerce.

Hazardous Substance (Environmental Protection Agency)

Any substance designated under the Clean Water Act and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) as posing a threat to waterways and the environment when released.

Extremely Hazardous Substance (Environmental Protection Agency)

Any substance extremely hazardous to the **community** during an emergency spill or release as a result of its toxicity, and chemical and physical properties. (**This definition triggers reporting requirements under SARA Title III.**)

Hazardous Waste (DOT and EPA)

Any **waste material** which is ignitable, corrosive, reactive, or toxic or which may pose a substantial or potential hazard to human health and safety and to the environment when improperly managed.

Hazardous Material (Ludwig Benner)

Any substance that jumps out of its container at you when something goes wrong and hurts or harms the things it touches.

The last one is a simplified working definition intended to give emergency responders an operationally accurate description of what constitutes a "hazardous material."

As stated earlier, it is hoped that you are already at the operations level in your hazardous materials training, but all the training in the world will not help a bit if responders fail to recognize the presence of hazardous materials. For that reason, a brief review of the clues available to detect hazardous materials is in order.

CLUES

All responders should constantly be alert for clues that could indicate the presence of hazardous materials. This applies to a response to any type of alarm. Many major hazardous materials incidents are not dispatched as "hazardous materials incidents." Many of them are dispatched as structure fires or medical alarms. It is only after the first-arriving units reach the scene that they discover the true nature of the alarm.

The Six Clues

- Occupancy and location.
- Container size and shape.
- Markings and color.
- Placards and labels.
- Shipping papers.
- The human senses.

Responders are trained to anticipate the nature of the call to which they are responding. Based on the information provided through the dispatcher, they should be thinking about what they might expect. They should anticipate a possible hazardous materials involvement as they approach an alarm. A first tip-off would be the location of the alarm. There are some locations that are prone to hazardous materials emergencies. An example would be a port area or an area heavy with industry. Usually, the first clue one thinks of is the occupancy and its location.

Clue 1: Occupancy and Location

Occupancy refers to the structure, to what is inside a structure, and to what is going on in the structure. As in the example above, often the location of the structure can provide insight into what one will find upon arrival.

Clue 2: Container Size and Shape

The size and shape of any containers present must be considered carefully. There are vast differences between an incident involving a 1-gallon container of a substance and one involving a 1,000-gallon container of the same substance, especially if it is toxic or highly explosive.

The shape of the container tells a lot about the product, too. The long, narrow cylindrical shape of a tanker carrying a heavy chemical is different from that of a vehicle with bottom unloading capability that carries a powder such as cement.

Clue 3: Markings and Colors

Markings or colors, such as the Union Carbide logo, the Exxon logo or the logo of any other company known to deal in chemical commodities, is often a clear sign of the involvement of hazardous materials.

Clue 4: Placards and Labels

There is an elaborate system using placards and labels to indicate the presence of hazardous materials. However, it is important to stress that placards may not always be used when they should be, or they may be used wrongly. Some hazardous materials specialists estimate that this occurs about 50 percent of the time.

Individual labels on the containers are considered to be much more accurate than placards, but they are smaller, so one must be closer to read them. The practice of using binoculars is an excellent one.

Clue 5: Shipping Papers

If the incident involves a transported commodity, shipping papers may be present. They will list any hazardous materials in the cargo and will give a quantity and manufacturer's name and phone number.

These papers have different names depending on whether they are found on a truck, a plane, or a ship. Some of the common names for shipping papers are bill of lading, waybill, consist, dangerous cargo manifest, airbill, etc.

Clue 6: The Human Senses

Technically, the five senses are not clues. They are the means by which we interpret the other clues. Nonetheless, in almost all situations one's sight and hearing play a key role in figuring out the nature of the problem.

The other senses--taste, touch, and smell--are potentially dangerous "clues" because they imply either proximity to the source of the problem or some kind of physical contact with it. One needs to be extremely careful in using them to detect the presence of hazardous materials.

As stated above, using other devices such as binoculars, measuring devices, gas sensors, etc., to aid the senses is the smart thing to do.

MECHANISMS OF HARM

Hazardous materials are capable of doing many terrible things to people, property, and the environment. Regardless of the many things that can happen, the mechanisms of harm fall into seven types of causes. These can be remembered with a simple mnemonic: TEAM CPR.

Mechanisms of Harm

Thermal
Etiological
Asphyxiant
Mechanical
Chemical
Psychological
Radiological

Thermal

Thermal refers to those events related to temperature extremes. High temperatures are common at fire-related incidents, but we often forget or ignore the potential for injury from extreme cold. Also, there are degrees of potential harm from heat as will be seen later when we talk about heat stress.

Etiological

Etiological refers to uncontrolled exposure to living, disease-causing microorganisms. Diseases commonly associated with etiological harm include hepatitis, typhoid fever, and a number of influenza viruses. Some of the more frightening etiological agents are associated with germ warfare.

Asphyxiant

Many materials can displace oxygen when released in confined environments; among them are nitrogen, carbon dioxide, and natural gas. Asphyxiation can occur when chemicals interfere with the respiratory process. For example, carbon monoxide reduces the oxygen-carrying ability of the blood, and cyanide prevents oxygen from being absorbed into body tissues.

Mechanical

This includes injury caused by shock waves, impact forces, or the scattering of debris such as from shrapnel in an explosion or a blast. This avenue of harm must be considered in the light of possible contamination as well as injury. The lacerations or punctures to the skin from a mechanical agent can lead to complications if injurious substances penetrate the skin. We will talk more about this later in discussing the skin and dermal toxicology.

Chemical

It is probably very obvious that the body is affected by chemicals. Exposure to a corrosive substance such as nitric acid can cause severe and deep tissue burns or permanent eye damage. Other chemicals may enter the body and cause harm in other ways. Hydrofluoric acid causes bone damage. Anhydrous ammonia causes internal burns. Parathion damages the nervous system. In one sense, this is probably the most dangerous of all the mechanisms of harm because chemicals are so prevalent in our world.

Psychological

Often, when emergency responders deal with an incident, especially one that is bigger than usual, there is an enormous amount of stress and anxiety. Sometimes this stems from lack of sufficient knowledge about how to operate; at other times, it stems from the inability to operate. One cause, surely a high stress inducer, is the deliberate choice not to act to save a victim's life when the lives of the responders are at equal or greater risk.

Radiological

Radiological agents are the last agents of harm. Energy released from radioactive sources such as alpha, beta, or gamma radiation can do serious harm to the body. Often, these harmful results can be long-lasting and can lead to death. Chernobyl is a prime example.

In summary, the mechanisms of harm are the standard ways the body gets hurt or suffers injury. Whatever negatively affects the body and threatens its well-being has reached the body through one of the mechanisms of harm.

This course will talk about exotic chemicals and deadly poisons; all of them will do harm in one or more of the seven ways listed above. In a way, this somewhat simplifies our study of toxicology, as we will see later.

HAZARDOUS MATERIALS CLASSIFICATIONS

The United Nations (UN) and the U.S. Department of Transportation (DOT) have devised a way to classify hazardous materials based on the chemical and physical properties of the product.

This DOT system is catalogued in the book with which most emergency responders are familiar: the *Emergency Response Guidebook*.

The following table summarizes the ten categories and their subdivisions. (This table reflects new classifications which, as of March 1, 1995, do not yet appear in the *Emergency Response Guidebook*.)

DOT Classifications

Category 1: Explosives

Class A: Explosives that will detonate, burn at 1,250 feet per second, and produce a shock wave.
Examples: Dynamite, blasting caps, nitroglycerin, and most military explosives.

Class B: Explosives that deflagrate and burn at less than 1,250 feet per second.
Examples: Special fireworks, liquid rocket propellants, and flash powders.

Class C: Substances that contain Class A and Class B components in limited quantities.
Examples: Most fireworks, small-arms ammunition, safety fuses, and paper caps.

Blasting Agents: Substances that are relatively insensitive.
Examples: Ammonium nitrate and fuel oil (ANFO).

Category 2: Gases

Flammable gases such as propane, methane, and hydrogen.

Nonflammable gases: Their primary hazard is cylinder failure when stored under pressure.
Examples: Neon, helium, and carbon dioxide.

Poison gases (Poison A): Gases that vaporize easily, and that are very dangerous to life, even in small amounts.
Examples: Cyanide, hydrocyanic acid, and diphosgene.

Oxygen.

Chlorine.

Category 3: Flammable and Combustible Liquids

Flammable liquids: Liquids with a flashpoint below 100°F, such as gasoline and alcohol.

Combustible liquids: Liquids with a flashpoint between 100° and 200°F, such as pine oil, fuel oil, and plastic solvents.

Category 4: Flammable Solids

Flammable solids: Solids likely to cause fires through friction or retained heat from manufacturing or processing or that are easy to ignite.
Examples: Matches or sulfur.

Flammable solids that are reactive with water: Solids that, when in contact with water or organic substances, may initiate or intensify fires.
Examples: Potassium, sodium, aluminum, or magnesium.

Category 5: Oxidizers

Oxidizers: Materials that readily yield oxygen to support combustion
Examples: Chlorate, permanganate, and nitrates.

Organic peroxides: Unstable chemicals containing carbon and oxygen that may detonate.
Examples: Benzoyl peroxide, methyl ethyl ketone peroxide.

Category 6: Poisons

Poison B: Liquids or solids that pose a serious health hazard to humans.
Examples: Parathion, potassium arsenate.
Irritants: Liquids or solids that give off dangerous or extremely irritating fumes when exposed to air or fire.
Examples: Tear gas, xylyl bromide.

Etiologic or infectious organisms: Living organisms or their toxins that can cause disease in humans.
Examples: Anthrax, botulism, polio virus.

Category 7: Radioactives

Radioactive I: Substances that register 0.5 or fewer millirems/hour on the external surfaces of containers.
Example: Chromium 51.

Radioactive II: Substances that register no more than 1.0 millirem/hour at 3 feet from external points or containers.
Example: Iodine 131.

Radioactive III: Substances that register more than 50 millirems/hour at external points, or more than 1 millirem/hour at 3 feet.
Examples: Cobalt 60, Strontium 90.

Category 8: Corrosives

Liquids or solids that damage human tissue or steel on contact.
Examples: Sulfuric acid, nitric acid, ammonium hydroxide.

Category 9: Miscellaneous

Dangerous goods or dangerous wastes which may or may not need to be placarded. These depend mostly on the quantity for classification.

Category 10: Other regulated materials

Materials that are a reduced risk because of limited quantities or other characteristics. Placards are not required.

A: Materials with anesthetic, irritating, or noxious properties that can cause discomfort to passengers or crew during transport.
Examples: Ether, chloroform, or solid carbon dioxide.

B: Substances that can cause significant damage to the transporting vehicle or container if released.
Examples: Metallic mercury, copper chloride.

C: Materials unsuitable for shipment unless properly packaged.

D: Materials of limited hazard because of form, quantity, or packaging.
Examples: Oiled materials, metal borings.

E: Materials not specified elsewhere, including hazardous wastes.

The arena of hazardous materials is a vast one and growing daily. Emergency responders face difficult situations when they respond to an incident that involves hazardous materials, and, more and more, this is becoming the rule rather than the exception.

Therefore, emergency medical responders need to know what they are up against in order to respond safely and effectively. Responders must understand what contamination is and how it affects them.

PROTECTION OF MEDICAL PERSONNEL INVOLVED IN DECONTAMINATION EFFORTS

Contamination

A contaminant is any substance capable of causing harm to life, to one's health, or to the environment. Contamination occurs when a spilled or released material physically contacts a person or thing. This usually is called direct or primary contamination. The substance (liquid, solid, or vapor) actually touches the body or thing.

Methods of Contamination

Contamination occurs in one of two ways: direct and cross. Direct contamination results when someone or something has direct contact with a contaminating substance. This is presumed to happen to anyone or anything entering a hot zone at a hazardous materials incident.

Cross-contamination occurs as a result of someone or something coming into contact with a person or object that has been contaminated. This would happen whenever hot zone operating personnel, equipment, or contaminated victims are not effectively decontaminated. As they leave the hot zone, they contaminate other persons or things outside the hot zone.

Contaminant Characteristics

Contaminants may have one or more characteristics that make them dangerous. These characteristics include the following:

- the potential health impacts;
- the routes of exposure, the anticipated level of tissue destruction, and the target tissues or organs;
- the physical state;
- the form the substance comes in, whether paste, gel, slurry, or suspension; and

- its incompatibility or reactivity with any other substances or temperature changes, and its water solubility.

Hosts

The things that can become contaminated or act as "hosts" include people, exposed objects, and the environment. The environment includes all living organisms, surface and subsurface soils, the atmosphere, oceans, and waterways.

While environmental decontamination (cleanup) is normally not one of the functions of an emergency response agency, oversight of such operations may be.

Decontamination

Fortunately, there are ways of dealing safely with contamination. Decontamination is "the removal of hazardous substances from employees and their equipment to the extent necessary to preclude foreseeable health effects" [The Occupational Safety and Health Administration (OSHA), U.S. Department of Labor].

The National Fire Protection Association (NFPA) defines decontamination as a chemical and/or physical process which reduces or prevents the spread of contamination from persons or equipment.

Combining elements from the above statements, we come up with the following definition of decontamination.

It is a chemical and/or physical process used to remove and prevent the spread of a contaminant from an emergency scene, because of the contaminant's ability to cause harm to living beings and/or to the environment.

Phases of Decontamination

The two major phases of decontamination are gross and secondary. (There is a third or tertiary decontamination phase, but it usually occurs at a medical facility and may involve such processes as sterilization or debridement.)

Gross Decontamination

This is the removal or chemical alteration of the majority of the contaminant. It must be assumed that some residual contamination always will remain on the host. This residual contamination can produce cross-contamination.

Secondary Decontamination

This is the removal or alteration of most of the residual product contamination. It provides a more thorough decontamination than the gross effort. However, some contamination still may remain attached to the host, resulting in permeation and impregnation.

Decontamination Mechanisms

There are seven common mechanisms for performing gross and secondary decontamination: emulsification, chemical reaction, disinfection, dilution, absorption, removal, and disposal.

Emulsification

This is the production of a suspension of ordinarily immiscible/insoluble materials, using an emulsifying agent such as a surfactant, soap, or detergent. Emulsification is most often used for nonpolar liquids and insoluble solids.

Chemical Reaction

This is a process that neutralizes, degrades, or otherwise chemically alters the contaminant. Normally, a chemical reaction does **not** assure that all hazards have been eliminated, and the reactions can be both difficult and dangerous to perform. It is, therefore, **not** recommended for use on living tissue.

Disinfection

This process removes the biological (etiological) contamination hazards as the disinfectant destroys microorganisms and their toxins.

Dilution

This process simply reduces the concentration of the contaminant. It is most commonly used for those substances that are miscible/soluble. Huge quantities of solvent may be required to dilute even small volumes of some solute contaminants.

Absorption

This is the penetration of a liquid or gas into another substance. A classic example of this process is when a sponge absorbs water.

Removal

This is the physical process of removing contaminants by pressure or vacuum. Most efforts involve the use of water, though such solids can be removed with brushes and wipes, and even air can be used.

Disposal

This process is the aseptic removal of a contaminated object (personal protective equipment, other equipment, etc.) from a host, after which the object is directly disposed of. The host object is never really decontaminated. Disposal most often is performed by personnel wearing protective equipment.

Decontamination Methods

There are two basic methods of decontamination: dry and wet.

Though a contaminant may or may not be a liquid, dry methods are an effective means of decontamination. These include the mechanisms of disposal and absorption, which use no liquids. Equipment may be vacuumed, or disposable outer suit coverings may be worn, providing what is known as double enveloping. Wet methods, though they may have some dry operational steps, principally involve the use of liquids. Wet methods are used in emulsification and dilution operations.

The decontamination mechanisms of disinfection, chemical reaction, and removal all may occur through either a wet or dry method.

Decontamination Mechanisms and Methods

Method	Mechanism
Dry	Absorption or disposal
Wet	Emulsification or dilution
Either	Chemical reaction, removal, or direction

Water-Based Methods

The wet solutions may be either water-based or nonwater-based. The water-based solutions may function as emulsifiers, neutralizers, degraders, or disinfectants.

Emulsifiers

Emulsifiers have something of a "loosening" effect on the bonding nature of a contaminant. Laundry detergent, preferably liquid, would be an emulsifying agent. Trisodium phosphate would be another, but is deemed too harsh because of its capacity to destroy the protective qualities of PPE. In itself it is a potential hazard to the environment.

Neutralizers

These are used to negate the destructive forces of either an acid or a base (caustic or alkaline). Strong acids and strong bases have pHs at the extreme ends of the pH range. The acids are less than 7 and grow stronger as the pH gets closer to 1. The bases are greater than 7 and grow more caustic as they move toward 14. The object of neutralization is to modify the pH of the contaminating substance to the point where it poses no danger. Whether it is an acid with a pH of 1.5 or a base with a pH of 13.5, the object is to get the pH as close to 7 (neutral) as possible. Sodium carbonate or the like might be used to neutralize an acid. Something on the order of citric, ascorbic, or acetic acid could be used to neutralize a caustic.

Degradation Solutions

Such solutions may be quite complex, as they often must be contaminant-specific. This means that general answers cannot be offered. Specific solutions to a given problem may require the use of chemical and/or biological agents. In one instance, chemical oxidation or reduction may solve a problem. In another case enzymes or microbial agents may be necessary. Resolving some of these contamination situations will require medical expertise.

Disinfection Procedures

These most commonly involve chlorine bleach; the Centers for Disease Control and Prevention (CDC) still believe that it is the best means of disinfection. But, like nearly all things, chlorine bleach has its drawbacks. Whether used "straight up" or diluted, the chlorine may affect equipment. All known alternative means of disinfection may cause comparable damage and pose other dangers as well.

Nonwater-Based Methods

Nonwater-based solutions, like those used for degradation operations, are contaminant-specific. In general, they are used for equipment only, because they are hydrocarbon and halogenated hydrocarbon compounds. The short alcohol molecules as well as the straight, cyclical, and ring-based molecules are, to different degrees, miscible with various hydrocarbons. Consequently, they assist in emulsion reactions. Carbon tetrachloride and other halogenated hydrocarbons also are good, but even infrequent contact with some of these products should be avoided.

Types of Decontamination

Mechanical Removal

Mechanical removal involves the wiping away of the material, or brushing off the material from the surface to be decontaminated. This method is used mostly for solid contaminants such as dusts and powders, which may be water reactive or are more hazardous when mixed with water.

Responders must take special precautions to prevent both the victim and the rescuers from inhaling the airborne dusts and vapors while performing mechanical removal.

Dilution With Water

Dilution reduces the concentration and strength of the hazardous material. This is the most common type of decontamination emergency workers use in the field. Irrigating solutions such as Ringers or saline are used to remove material from the eyes and small areas of the human body.

Responders must exercise caution with products that are water reactive because chemical or thermal burns on the patient may occur in some cases. Know the product before you act.

This method may not be effective with nonwater-soluble materials which may require other agents. Dilution is an impractical solution for large-scale equipment or environmental decontamination, because the liquid used to decontaminate becomes a hazardous waste. It may get into waterways or the groundwater if containment is not practical.

Absorption

This method has no practical role in the decontamination of victims. This is generally used for large-scale removal of contaminants from the environment, such as from the surface of water. Absorbent pads and booms are useful for lighter-than-water products, while "kitty litter" is good for petroleum spills on solid surfaces.

Degradation

This is the chemical alteration of a hazardous material into a harmless substance. Precautions must be used to protect against side effects of this method, such as heat generation when an acid and base are mixed together. Neutralization is a prime example of degradation.

This method is not a practical method to use for patient decontamination.

Isolation and Disposal

This method packages the contaminated items and disposes of them at a waste site or incinerator. For this reason, it is not the method of choice in dealing with patients, but is likely to be used in dealing with the contaminated clothing of victims and emergency workers.

Disinfection

This is the method of choice for many biohazards. We use many products routinely for disinfection of biohazards such as bleach, hydrogen peroxide, and some commercial products for skin cleaning after medical emergency responses.

Setting Up for Decontamination

The specific type and level of protection required for decontaminating personnel and doffing attendants vary, depending on the exact situation and contaminant involved. A general rule of thumb is that decontamination personnel will wear protection of the same level or one level below that of personnel being decontaminated.

Access and decontamination corridors are set up adjacent to one another in the warm zone. They are normally a minimum of 25 feet wide. They only need to be between 30 and 50 feet in length, depending on the number of operational steps required and options available. They extend from the inner ring of the cold zone to the outer perimeter of the hot zone.

The precise decontamination approach to be taken and the physical setup will vary depending on whether it is decontaminating protected or unprotected people, equipment, or all three. It also depends on the properties of the contaminant and other circumstances surrounding the incident. Much must be considered.

PERSONAL PROTECTIVE EQUIPMENT (PPE)

PPE guidelines are required as part of an employer's written safety and health program under 29 CFR 1910.120 and 40 CFR 311. The guidelines must include the following elements:

- Selection, based on hazards that are specific to an incident site, as well as the anticipated equipment use, limitations, and anticipated duration of activity.

- The establishment, implementation, and enforcement of standards for maintenance, storage, decontamination, and disposal of PPE.

- Provisions for the proper fitting of all personnel with appropriate protective equipment and for adequate training in donning, doffing, and using the various suits as well as inspection procedures before, during, and after every use.

- The implementation of an ongoing evaluation effort to establish the effectiveness of the entire program.

- The establishment, implementation, and enforcement of a system that addresses the medical concerns of all employees, in view of the extreme conditions under which personnel must work.

Types of PPE

While there are many types of protective clothing and applications, we will cover only those which hazardous material responders most commonly use. These are chemical, thermal, and full fire protection equipment.

Chemical Suits

Selection of the appropriate garment depends on the level of operation to be performed. There are four such levels: A through D.

Level A

This level of chemical protective equipment is appropriate when one needs the greatest level of dermal, respiratory, and ocular protection. Level A equipment is worn under the following conditions:

- A product has been identified as hazardous.

- The strength and concentration of vapors, gases, or particulates warrant extreme caution.

- There is the likelihood of a liquid splash on personnel or the danger of personnel becoming immersed in the product.

It also would be worn when the product has not yet been identified definitively, and operations are to occur in confined or poorly ventilated areas.

Level A Components

1. Positive-pressure, self-contained breathing apparatus (SCBA) with a full facepiece.
2. Totally encapsulating chemical protective suit.
3. Chemically resistant inner and outer gloves and boots.
4. Boots with steel toes and shanks.

Options

A. Disposable outer suit.

B. Long underwear, coveralls, and a hardhat.

Level A equipment consists of both respiratory and body protective components. First, it includes positive-pressure, self-contained breathing apparatus (PP-SCBA) with a full facepiece. Secondly, it includes a totally encapsulating chemical protective suit, as well as chemically resistant inner and outer gloves and boots of the same nature. The boots should have steel toes and shanks. A disposable protective suit may be worn over the totally encapsulated one. Optional equipment might include long underwear, coveralls, and a hardhat.

Level B

Responders should wear Level B protective equipment when they need the highest level of respiratory protection, but there is a lesser concern regarding skin tissue. For example, when the oxygen level in a given area is below 19.5 percent by volume, and the atmosphere provides no threat of toxin absorption or damage to the skin, Level B would be appropriate.

Level B Components

1. PP-SCBA with a full facepiece (or, NIOSH-approved PP-air respirator).
2. Hooded, chemical-resistant clothing such as overalls, long-sleeved jacket, splash suit.
3. Chemical-resistant inner and outer gloves and boots.
4. Boots with steel toes and shanks.

Options

A. Chemical-resistant boot covers.

B. Hardhat.

C. Faceshield.

D. Coveralls.

Level B consists of a PP-SCBA with a full facepiece or a positive-pressure-supplied air respirator with escape capability, approved by the National Institute for Occupational Safety and Health (NIOSH). Also required is some form of hooded chemical-resistant clothing like overalls and a long-sleeved jacket, a one- or two-piece chemical splash suit or disposable chemical-resistant overalls. Chemical-resistant inner and outer gloves, and boots with steel toes and shanks, also shall be worn. A member may, optionally, choose to wear chemical-resistant boot covers, a hardhat, faceshield, and coveralls.

Level C

This level of chemical protective clothing is to be worn when the product type and concentration provide no hazard to the skin and the quality of the atmosphere is such that air-purifying respirators would be adequate against airborne contaminants.

Level C components include hooded, chemical-resistant garments. For example, in addition to the head covering, this could include coveralls, a one- or two-piece chemical splash suit, or disposable chemical-resistant overalls.

Level C Components

1. Hooded, chemical-resistant garments.
2. Full or half-mask air-purifying respirator (NIOSH approved).
3. Chemical-resistant inner and outer gloves and boots.
4. Boots with steel toes and shanks

Options

A. Chemical-resistant boot covers.
B. Hardhat.
C. Faceshield.
D. Coveralls.
E. Escape mask (NIOSH approved).

Also required are a full or half-mask air-purifying respirator that has been approved by NIOSH, and chemical-resistant inner and outer gloves and boots, once again of the same nature, with steel toes and shanks. Optional apparel may include chemical-resistant boot covers, a hardhat, faceshield, coveralls, and an escape mask approved by NIOSH.

Emergency responders normally do not use the above-mentioned respirators. The product first must be identified; then the specific cartridge is selected for the product used. Respirators are **not** generic. Use of such devices should follow departmental SOPs very closely.

Level D

This level of protection must be worn where a uniform providing minimum protection would be adequate. It would be useful for nuisance levels of contamination only, where there is no known hazard and the work functions preclude splashes, immersions, or the potential for unexpected inhalation or contact with any hazardous chemicals.

Level D Components

1. Chemical-resistant boots.
2. Boots with steel toes and shanks.
3. Safety glasses or chemical splash goggles.

Options

A. Gloves.
B. Overalls.
C. Chemical-resistant boot covers.
D. Hardhat.
E. Escape mask (NIOSH approved).
F. Faceshield.

Level D components include chemical-resistant boots with steel toes and shanks, safety glasses, or chemical splash goggles.

Optional items are gloves, overalls, chemical-resistant boot covers, hardhat, escape mask (NIOSH approved), and faceshield.

Structural Firefighting Protective Clothing

Commonly known as "turnouts," this equipment is designed for fire suppression operations. Turnouts may be made of several materials, so long as they meet safety performance standards. The components include the familiar helmet, coat, boots, and gloves. Some communities go so far as to require that their personnel wear flame-retardant hoods.

PPE Use and Limitations

Deciding what type of protective clothing to wear at an incident is based on many factors. The material of the suit must be compatible with the nature of the incident. Whether dedicated or disposable, the suit must be able to resist tears, abrasions, punctures and temperature effects. Its stitching and multi-layered insulation, for example, should not fall apart during an operation The garment assembly should provide some level of comfort and flexibility. Auxiliary equipment such as boots and gloves also should fit well.

Finally, because it deserves to be thought of last when lives are at stake, there is the cost. Undoubtedly, financial constraints will affect the kind and number of suits a hazardous materials team will have, just as cost determines the personnel, equipment needs, and training levels.

Testing

There was a time when the chemical compatibility of suits was tested against as many as 114 chemicals. Presently, compatibility is evaluated by the measured effects of exposure to chemicals having only 14 differing derivative bases. Each manufacturer of protective clothing has the garments tested, and publishes a booklet containing the test results showing the chemically compatible natures of their product. The booklet is distributed, along with any suits purchased. Some books have generic compatibility charts.

The testing essentially measures the amount of time it takes for given substances to break through the barrier provided by the protective clothing. The validity of these charts always has been questionable. The industry pays the independent testing labs for their services. Since not all chemicals are tested on the suits, the charts have very limited value. Furthermore, the information **may** reflect the suit's level of compatibility during its first exposure only. What about its second? What about the synergistic effects of multiple and simultaneous chemical exposures? Reports do not cover this.

Equipment Breakdown

PPE may break down upon its first use, or only after many uses. The cause for the failure would probably be penetration, degradation, permeation, or some combination of the three.

Penetration

This occurs when product manages to enter the suit through the protective barriers at zippers, seams, and faceshields, or holes created by garment imperfections, tears, and punctures.

Degradation

This is the physical destruction of the material through single or multiple exposures to chemicals.

Permeation

Permeation is the molecular movement of chemicals through the exterior protective barrier of a suit. This may happen just a little at a time, each time that a garment is worn, until permeation has become so complete that decontamination becomes impossible.

Work Mission Duration

When the SCBA alarm sounds during firefighting, one usually has time to reach an area of safety and air. This is not always the case for hazardous materials personnel. They must allow time for decontamination. Running out of air shows poor planning and negates all the good work that went into providing proper protection before responders entered a hazardous materials hot zone.

While work mission duration guidelines affect all protective equipment, some garments, like gloves, do not require a formula to ensure their ability to function safely. However, the same cannot be said about one's air supply. The volume of air present in a given SCBA depends on the size of the cylinder. This is clear-cut. The amount of "use time" one can get from an air bottle, however, is not as easily established.

Mine safety personnel experimented with one method to determine this value. By using three bottles of air with different volumes, they determined the size that would provide the average volume of air sufficient to supply the wearers for 30, 45, and 60 minutes, as shown in the following table. The mask wearers were typing, filing, and doing related office work during the tests. Therefore, it seems a safe conclusion that their "use times" are not exactly a reliable means of gauging the amount of time a similar-sized bottle would supply the needs of an emergency responder.

Work Mission Statement

	Operational Time			
Supply Safety	30 min.	45 min.	60 min.	Umbilical
	-13	-15	-20	???
	17	30	40	???
Travel (x2)	-05	-05	-05	???
	12	25	35	???
Decon (x #)	-05	-05	-05	???
	7	20	30	???
Workload	-05	-05	-05	???
(H=10 M=5 L=O)*	2	15	25	???
Environmental	-05	-05	-05	???
Operational Time	**-03**	**10**	**20**	**???**

***10 =<90°F**
5 = 85°F to 90°F
0 = >85°F

These research data are the basis of the table above. The balance of the chart is drawn from a consensus of research performed within the fire service. The 30-minute bottle, you will note, was 3 minutes short of being able to provide enough time for operations. After allowing for a safety factor of 13 minutes, travel of 5 minutes, and an approximate anticipated decontamination time of 5 minutes plus 5 minutes more for environmental factors, the chart suggests that a 30-minute bottle may not be adequate.

Safety factors must be built into any system used, to assure the maximum amount of protection. Since all of us breathe at varying rates under differing circumstances, those variables must be included in any estimate of a given user's needs. Recognition of those differences helps compensate for the across-the-board ratings given air supply systems in general use.

Travel Time

Travel time must be calculated from the moment that personnel "go on air," that is, at the edge of the hot zone, until the moment the point of operation is reached. That time is then doubled to allow for exit time. If reconnaissance, search, and rescue are required, then the travel time to the most distant point required to accomplish these objectives also must be calculated. If one may have to carry a victim, the time to exit, over the same distance traveled on the way in, also will increase by some measure. The air expended in performing those acts is calculated separately.

Decontamination Time

Decontamination time will affect "user time," in that the greater the number of people to be decontaminated, the longer each succeeding one of them will have to remain on air. Let us assume there are three responders to be decontaminated. The first takes five minutes, the second waits five minutes and decontaminates in five, and the third waits ten minutes and decontaminates in five. The last individual had to spend ten more minutes on air than did the first. These differences must be calculated long before the decontaminating operation begins. They must, in fact, be recognized at the moment of entry.

Workload Time

This time varies at every incident. As we work harder and longer, our breathing becomes more labored. We breathe more heavily, deeper, and faster. This must be recognized and calculated in "user time" estimates. Good judgment and common sense should prevail. Supervisors should know both the strengths and limitations of personnel under their command. The effects of heavy work, such as rescue and overpacking, will make greater physical demands on some personnel than on others. The same could be said in general about medium work efforts, such as plugging and patching, or even light work, such as monitoring. These are not always things that can be measured easily, and it is here that supervisors must make some value judgments without benefit of a slide rule.

Environmental conditions affect our work performance and health, particularly since we are performing under emergency operating conditions. Health professionals may not always be available to determine the time that personnel should be spending in protective clothing. As this is most often the case, the following guide is offered to help show the effects of temperature and its relationship to anticipated air depletion.

Temperature (°F)	Reduction of Time Spent in Protective Clothing
< 85°F	0 Minutes
85° - 90°F	5 Minutes
> 90°F	10 Minutes

The above table is an example and should be modified to suit the personnel in one's agency and to accommodate one's geographical area.

Some units in consistently warm climates would be a great deal more accustomed to temperatures in the 80°F range than someone from Alaska, Maine, or even Virginia.

Umbilical Cords (Supplied-Air Breathing Apparatus/SABA)

These cords also are used to supply air. Though they obviously can provide extended use, their limitations are many. Besides the impossibility of use in a flame-filled environment and the impacts of those items mentioned above, ANSI/OSHA identify that the maximum effective length of the hose is 300 feet. It is difficult to drag and is likely to be nicked, stretched, or torn, and to come into contact with puddles of corrosives and the like. It also presents a tripping hazard and must be held at the user's end, leaving users with only one free hand.

If an umbilical cord is used, the member also must wear an escape bottle of compressed air.

Maintenance and Storage

Since there are so many types of protective garments, we can cover the subject only in general terms. The point cannot be made too strongly that we should follow the recommendations of any manufacturer concerning the required care and maintenance of PPE. It can only help to ensure extended use and safe results.

Chemical protective clothing should not be exposed to unnecessary ultraviolet light. Suits should be maintained clean, as dirt and grime can be abrasive and substantially reduce a garment's useful life. Sanitizing should be done to prevent the spread of germs to other wearers of reusable garments.

If the clothing is not stored properly, stresses can damage the suit. When hanging suits, avoid creating sharp creases which may cause weaknesses and eventual damage to the material. The clothing should not be hung on sharp or pointed hooks that may penetrate the garment.

Many of the garments can be expected to begin breaking down after two years. The glues, rubberized materials, and heated sealants dry out and crack; this may result in suit penetration.

Many assemblies are very expensive. Only the qualified and those authorized by the manufacturer should attempt repairs. Each manufacturer has its own standards for repairs. Even garments that may appear to be the same or meet the same chemical compatibility standards are **not** equal. What we can repair on one manufacturer's product, we should not even assume we can repair on another's. In addition, manufacturers will not accept garments for repair that are not certified as being clean, decontaminated, or free of product residue. Some manufacturers allow replacement of certain parts of their protective assemblies, such as faceshield lenses, boots, and gloves. Replacement parts should be installed following the manufacturers' recommendations.

Decontamination and Disposal

Protective clothing that is decontaminated still may have product that has already permeated the equipment. When doing decontamination, we are removing only the surface layer of the chemical. It may be difficult, if not impossible, to remove product that has permeated the garment. A great deal depends on sustaining the compatibility of a garment. When suits are used in multiple entries, breakthrough times of chemicals may be significantly different from the first time they were so exposed. We need to remember that the purpose of decontamination is to ensure the safe exit of personnel from the suit.

Since there are so many variables in protective clothing decontamination, a confidence factor exists when garments are worn more than once. As familiarity may lead to blind confidence, some agencies already have taken the attitude that disposables are the way to go.

Training and Proper Fitting

Training is a key element in wearing any form of protective clothing. The better trained an individual is, the better the chances of survival when something does go wrong. Simply to wear the clothing is not enough. Training gives the wearer an idea of the garment's operational limitations.

Chemical protective clothing comes in various sizes and fits a very broad variety of personnel. The garment should be made to fit the individual and not the other way around. Loose-fitting clothing tends to get caught or torn and can cause injury. On the other hand, tight-fitting clothing causes fatigue, restricts movement, and wears out faster. The thicker the garment, the heavier it is and the less effective will be the wearer's tactile sense required to perform many functions.

Donning and Doffing Procedures

All personnel using protective clothing should know the recommended procedures for donning and doffing, assisted and unassisted. Personnel should follow manufacturers' guidelines and their own department's SOPs.

Inspection Procedures

Procedures before, during, and after operations should include maintaining a record of all inspections; naming the inspector; stating the time the garment was cleaned, sanitized, and decontaminated; naming any chemicals encountered; listing the decontamination solutions used; noting the time and results of any leak tests and the name of the tester; making notations of defects found and identifying the discoverer; and listing names of all persons who have ever worn the garment.

Evaluation of the PPE Program's Effectiveness

The evaluation process is ongoing. With an ever-increasing ledger of information about operations, personnel, equipment, faults, and advantages, the need for change should become the only real standard. Evaluation of those records, and the development of new problems, new technology, and new equipment all mandate that the organization remain flexible and accept the inevitable need for change.

Medical Considerations

The department would be wise to keep records dealing with use limitations during temperature extremes and other appropriate medical information. Baseline health data should be established.

Records should be maintained as to what elements of the PPE program have an effect on personnel, such as work mission duration or the level or type of garments worn. Perhaps injuries are occurring too frequently; perhaps they are of a type that additional training, weight, or exercise programs might help stop. Perhaps there is a tool of some type that would require less physical effort to use for a task that seems to be contributing to pulled muscles, back injuries, and the like.

Accurate records reflecting the identities of substances to which members have been exposed also should be maintained, as well as any effects these substances are known to have on members.

Any and all of these records should be kept in a place secure from damage, prying eyes, tampering, or theft. Duplicate copies should be maintained elsewhere, and affected employees should be allowed, without unnecessary delay, to have access to those records for personal litigation or medical reasons. After all, they have risked their lives in the accumulation of the data, so the data belong to them as much as to the organization.

APPENDIX

CDC
CENTERS FOR DISEASE CONTROL AND PREVENTION

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MMWR

MORBIDITY AND MORTALITY WEEKLY REPORT

CDC
Surveillance
Summaries

Surveillance for Emergency Events Involving Hazardous Substances — United States, 1990–1992

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Surveillance for Emergency Events Involving Hazardous Substances — United States, 1990–1992

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Abstract

Problem/Condition: A review of existing reporting systems indicated that not enough information was being collected to determine the public health consequences of emergency events involving hazardous substances.

Reporting Period Covered: January 1990 through December 1992.

Description of System: State health departments in selected states collect and each quarter transmit information about the events, substances released, and the public health consequences of hazardous substance releases (i.e., morbidity, mortality, and evacuations) to the Agency for Toxic Substances and Disease Registry (ATSDR). Five state health departments (Colorado, Iowa, Michigan, New Hampshire, and Wisconsin) began data collection on January 1, 1990. On January 1, 1992, the reporting state health departments included those from Colorado, Iowa, New Hampshire, New York, North Carolina, Oregon, Rhode Island, Washington, and Wisconsin.

Results and Interpretation: During 1990–1992, 3,125 events were reported from participating states to ATSDR's Hazardous Substances Emergency Events Surveillance (HSEES) system. Of these events, 2,391 (77%) were fixed-facility events (i.e., occurred at stationary facilities), and 723 (23%) were transportation related. In 88% of events, a single chemical was released. The most frequently released hazardous substances were volatile organic compounds (18% of the total 4,034 substances released), herbicides (15%), acids (14%), and ammonias (11%). In 467 events (15% of all events), 1,446 persons were injured; 11 persons died as a result of these injuries. Respiratory irritation (37%) and eye irritation (23%) were the most frequently reported health effects. A total of 457 (15%) events resulted in evacuations; of these, 400 (88%) were ordered by an official (e.g., a police officer or firefighter). The median number of persons evacuated was 25 (range: from 12 to >9,999 persons). Evacuations lasted an average of 9.4 hours (median: 3 hours; range: 1–240 hours).

Actions Taken: Information from HSEES is being used for preparedness planning, such as the relocation of hazardous materials (HazMat) teams to areas with higher incidence and the training of first responders and employees. The information is also used to conduct follow-up epidemiologic studies and to determine risk factors associated with events resulting in injury.

INTRODUCTION

Since World War II, the number of chemicals that have been developed, produced, and used in the United States has increased rapidly. More than 65,000 substances are available on the market, and approximately 600 new substances are produced each year (*1*). However, the potential health effects of many of the substances in common use are unknown. Furthermore, comprehensive information regarding the public health consequences of hazardous substance releases (i.e., the morbidity, mortality, and evacuations of the general public, first responders, and employees*) was not available.

In 1988, the Agency for Toxic Substances and Disease Registry (ATSDR) initiated a study of the information about hazardous substance releases available in three national databases: the National Response Center Database, the Hazardous Materials Information System (HMIS), and the Acute Hazardous Events Database (*2*). These databases were found to have limitations for assessing the public health consequences of hazardous substance releases (*2–4*). Not all events were included in these databases (e.g., HMIS does not include events involving intrastate carriers and fixed [stationary] facilities), and many events were not reported. Moreover, the accuracy of the collected information could not be confirmed. Other types of data not included in these systems were information concerning the persons injured by hazardous substance releases, the types of injuries received, and evacuations.

Because of these limitations in data collection, in October 1989 ATSDR implemented an active, state-based Hazardous Substances Emergency Events Surveillance (HSEES) system in selected states to enable assessment of the public health consequences associated with hazardous substance releases. This report describes the public health consequences of events reported to the HSEES system from January 1990 through December 1992.

METHODS

Five state health departments (Colorado, Iowa, Michigan, New Hampshire, and Wisconsin) began data collection on January 1, 1990. On January 1, 1992, the reporting state health departments included those from Colorado, Iowa, New Hampshire, New York, North Carolina, Oregon, Rhode Island, Washington, and Wisconsin. Information regarding the event, chemicals released, affected persons, injuries,† and evacuations was recorded on standardized data collection forms designed by ATSDR. Personnel from state health departments used different sources (e.g., records or verbal reports by personnel of state environmental protection agencies, police and fire departments, and hospitals) to obtain information for the data collection form. The data were computerized, using a data entry system provided by ATSDR, and were reported quarterly to ATSDR.

Hazardous substance emergency events were defined as uncontrolled or illegal releases or threatened releases of chemicals or their hazardous by-products. The reportable chemicals included the 200 substances identified by ATSDR as the most hazardous substances found at Superfund sites (*5*), all other insecticides and herbicides in addition to those found at Superfund sites, chlorine, hydrochloric acid,

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*The term "first responders" refers to those persons whose occupations require that they respond immediately to emergency events (e.g., firefighters, law enforcement officers, emergency medical service personnel, and hazardous materials [HazMat] team members). "Employees" refers to persons employed by the company responsible for the hazardous event. "General public" refers to all other persons at the scene of the event.

†In this report, "injuries" includes all injuries and any other adverse health effects.

sodium hydroxide, nitric acid, phosphoric acid, acrylic acid, and hydrofluoric acid. Events were reported if the amount of substance released needed to be removed, cleaned up, or neutralized according to federal, state, or local law. In addition, events were reported if they resulted in a potential for a release of a designated hazardous substance and if this potential led to an action (e.g., an evacuation) to protect the health of employees, first responders, or the general public.

RESULTS

A total of 3,125 events were reported from participating states to the HSEES system during 1990–1992. Of these events, 2,391 (77%) were fixed-facility events, and 723 (23%) were transportation related. Type of event was unknown for 11 of the reported events. Location of event was known for 3,092 events. Most (1,890 [61%]) events occurred in areas with industrial or commercial land use; 547 (18%), in areas classified as rural; and 329 (11%), in residential areas.

The frequency distribution by day of week for Monday through Friday did not vary substantially. However, the daily average number of 538 emergency events on a Monday through Friday was more than twice the daily average number on a Saturday or Sunday (i.e., 219 events). Time of day that the emergency event occurred was known for 2,957 events. Of these, 2,230 (75%) events occurred from 6 a.m. to 6 p.m.; 467 (16%), from 6 p.m. to 12 a.m.; and 260 (9%), from 12 a.m. to 6 a.m.

The hazardous substances released during the events were grouped into 11 categories (Table 1). The most frequently released hazardous substances were volatile organic compounds (18% of the total 4,034 substances released), herbicides (15%), acids (14%), and ammonias (11%). The substances released during the two types of events were similar; however, a greater number of transportation-related incidents involved the release of herbicides.

For the four categories of substances that were released most frequently, 13%–27% of the releases resulted in injury. The substances released most often, however, were not necessarily those most likely to result in injury. For example, although insecticides were released in only 5% of all events, 80 (37%) of the 217 events with releases of insecticides resulted in injuries.

A single substance was released in 2,747 (88%) of all events, and two substances were released in 199 (6%). The distribution of the number of substances released during events that resulted in injury (Table 2) was comparable to the distribution of the number of substances released during all events.

In 467 events (15% of all events), 1,446 persons were injured. In 252 (54%) events resulting in injury, only one person was injured. In an additional 88 (19%) events resulting in injury, two persons were injured. Information about age was available for 883 (61%) injured persons (mean age: 33 years; range: 1–79 years). Seventy-six percent of injured persons were male. Overall, 968 (67%) injured persons were employees, 200 (14%) were first responders, and 276 (19%) were from the general public. In transportation-related events, 46 (34%) injured persons were first responders.

For both fixed-facility and transportation-related events, respiratory irritation and eye irritation were the most frequently reported health effects (Table 3). In transportation-related events, injured persons also commonly had traumatic injuries (i.e., 28 [13%] of transportation-related injuries were traumatic).

TABLE 1. Substances released during all hazardous substances emergency events and during all such events resulting in personal injury,[*] by chemical category — selected states,[†] Hazardous Substances Emergency Events Surveillance, 1990–1992

	Substances released				
	During all events		During events resulting in personal injury		
Substance category	No.	(%)[§]	No.	(%)[¶]	(%)[**]
Volatile organic compounds	727	(18)	93	(12)	(13)
Herbicides	588	(15)	126	(16)	(21)
Acids	553	(14)	148	(19)	(27)
Ammonias	448	(11)	103	(13)	(23)
Metals	261	(7)	21	(3)	(8)
Insecticides	217	(5)	80	(10)	(37)
Polychlorinated biphenyls	212	(5)	6	(1)	(3)
Bases	152	(4)	40	(5)	(26)
Chlorine	157	(4)	43	(6)	(27)
Cyanides	21	(1)	9	(1)	(43)
Unclassified	698	(17)	108	(14)	(15)
Total	4,034	(100)	777	(100)	

[*] Refers to injuries and all other adverse health effects.

[†] During 1990–1991, participating states included Colorado, Iowa, Michigan, New Hampshire, and Wisconsin. During 1992, participating states included Colorado, Iowa, New Hampshire, New York, North Carolina, Oregon, Rhode Island, Washington, and Wisconsin.

[§] Percentage of all substances released.

[¶] Percentage of all substances released during events that resulted in personal injury.

[**] Within the substance category, the percentage of substances released during events that resulted in personal injury.

TABLE 2. Distribution of number of chemicals released per hazardous substances emergency event with injured[*] persons — selected states,[†] Hazardous Substances Emergency Events Surveillance, 1990–1992

	Type of event								
	Fixed-facility			Transportation-related			All events[§]		
No. of chemicals released	Events No.	Events (%)	Total no. of chemicals	Events No.	Events (%)	Total no. of chemicals	Events No.	Events (%)	Total no. of chemicals
1	338	(85.1)	338	53	(76.8)	53	391	(83.9)	391
2	27	(6.8)	54	11	(15.9)	22	38	(8.2)	76
3	12	(3.0)	36	3	(4.3)	9	15	(3.2)	45
4	5	(1.3)	20	1	(1.4)	4	6	(1.3)	24
5	4	(1.0)	20	1	(1.4)	5	5	(1.1)	25
≥6	11	(2.8)	216	—	—	—	11	(2.4)	216
Total	397	(100.0)	684	69	(100.0)	93	466	(100.0)	777

[*] Refers to injuries and all other adverse health effects.

[†] During 1990–1991, participating states included Colorado, Iowa, Michigan, New Hampshire, and Wisconsin. During 1992, participating states included Colorado, Iowa, New Hampshire, New York, North Carolina, Oregon, Rhode Island, Washington, and Wisconsin.

[§] Location of one event was not known. A total of 467 events resulted in personal injury.

Eleven deaths were reported, two of which occurred during one event. Nine deaths occurred at fixed facilities, and two during transportation-related events. Eight persons who died were employees, one was a first responder, and two were from the general public. Demographic information was known for 10 persons who died; all were male (mean age: 43.5 years). Eight persons who died had not worn personal protective equipment, and nine had not worn eye protection. The conditions associated with these deaths were trauma, chemical burns, thermal burns, heat stress, cardiac arrest, and asphyxiation.

Most (869 [60%]) of the injured persons were treated at a hospital but did not require inpatient admission. Others were admitted to a hospital for treatment (220 [15%] injured persons), treated at the scene of the event (167 [12%]), or transported to a hospital for observation but required no treatment (88 [6%]). Sixty-seven (5%) injured persons were treated for their injuries by private physicians within 24 hours of the event.

Of the 1,353 injured persons for whom information concerning use of protective equipment was available, 984 (73%) were not using any type of personal protective equipment at the scene of the event. Of the injured employees, 676 (75%) were not using personal protective equipment. Hard hats and steel-toed shoes were worn by 136 (15%). Of the injured first responders, 40 (22%) used no personal protective equipment, 77 (43%) used firefighter protective gear, 34 (19%) used Level B protection, and 22 (12%) used Level A protection.*

Approximately 457 (15%) of events resulted in evacuations, of which 400 (88%) were ordered by an official (e.g., a police officer or firefighter). In 40 (1%) events, per-

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*[*Level A*] protective equipment provides the highest level of protection for skin, eyes, and the respiratory system and includes a respirator and chemical-resistant suit, gloves, and boots. *Level B* protective equipment provides a high level of respiratory protection, but less skin protection than Level A.

TABLE 3. Types of injuries* sustained during emergency events involving hazardous substances — selected states,† Hazardous Substances Emergency Events Surveillance, 1990–1992

Type of injury	No. of injuries	Percentage
Respiratory irritation	933	37.3
Eye irritation	571	22.8
Nausea	222	8.9
Chemical burns	153	6.1
Dizziness or other central nervous system symptoms	126	5.0
Skin irritation	96	3.8
Physical trauma	82	3.3
Headache	80	3.2
Heat stress	49	2.0
Thermal burns	26	1.0
Vomiting	8	0.3
Other	155	6.2
Total	**2,501**	**100.0**

*Refers to injuries and all other adverse health effects.

†During 1990–1991, participating states included Colorado, Iowa, Michigan, New Hampshire, and Wisconsin. During 1992, participating states included Colorado, Iowa, New Hampshire, New York, North Carolina, Oregon, Rhode Island, Washington, and Wisconsin.

sons in the affected areas were instructed to stay indoors. The median number of persons evacuated was 25 (range: from 12 to >9,999), and evacuations lasted an average of 9.4 hours (median: 3 hours; range: 1–240 hours). For 116 (29%) of the evacuations ordered by an official, the evacuation zone was defined as a circle or radius around the site of the event. For 33 (8%) evacuations, no criteria were used for defining the evacuation zone. For 52 (13%), the evacuation zone was downwind from the location of the hazardous substance release; for 192 (49%), the affected building or part of the building was evacuated. Evacuation criteria were not known for seven events.

DISCUSSION

The information from the events reported to the HSEES system during 1990–1992 indicates that public health consequences (i.e., the morbidity, mortality, and evacuations) may be associated with approximately 15% of hazardous substance releases. These estimates, combined with other information, such as the number and types of substances most likely to be released (e.g., volatile organic compounds, acids, ammonias, and herbicides) and the substances most likely to be associated with injuries (e.g., insecticides), may be used to help develop prevention strategies. For example, knowledge regarding the characteristics of hazardous substance releases and the associated public health consequences may allow formulation of guidelines for primary prevention (i.e., prevention of hazardous substance releases) and secondary prevention (prevention of morbidity and mortality as a result of hazardous substance releases).

The information provided by the HSEES system is used to train first responders, to plan for emergency preparedness, and to conduct follow-up epidemiologic studies. Trends in the spatial distribution of events are used for relocating HazMat (first responder) teams to areas with higher frequency of events. Effective statewide interventions to prevent public health consequences from hazardous substance releases should reduce the number of injuries associated with such events.

Limitations of the HSEES system during the 1990–1992 reporting period included the nonrandom selection of participating states and the narrow definition of an emergency event. To improve the representativeness of these data for the United States, the system has been expanded to additional states and the number of reportable substances has been increased. The definition of an emergency event was expanded January 1, 1993, to include all hazardous substances except petroleum products. This new definition will increase the likelihood of detecting public health consequences from releases of newly developed and produced substances.

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ATSDR'S 24-HOUR EMERGENCY RESPONSE LINE
(404) 639-0615

ATSDR's Emergency Response and Consultation Branch, Division of Health Assessment and Consultation, provides assistance on health issues surrounding the release or threat of release of hazardous materials.

The following experts are available for consultation and advice:

- within 10 minutes, an emergency response coordinator;
- within 20 minutes, a preliminary assessment team consisting of a toxicologist, chemist, environmental health scientist, physician and other health personnel as required;
- within 8 hours (if incident necessitates), an onsite response team.

UNIT 3:
STANDARD OF CARE

OBJECTIVES

The students will be able to:

1. *Working alone, define Standard of Care (SOC).*
2. *Working alone, differentiate between liability, negligence, and gross negligence.*
3. *From a list and working alone, select the federal laws and regulations that pertain to hazardous materials response.*
4. *Working alone, define consensus standard and identify the major relevant consensus standards for hazardous materials response.*
5. *Working alone, explain the relationship of toxicology to hazardous materials response.*
6. *Working alone, define the key toxicological terms used in hazardous materials response when dealing with toxic concentrations.*
7. *Working in a small group, and given an objective statement from an agency's policy, identify permissible activities and training needs that meet the stated objective.*
8. *Working alone, and with the list of permissible activities and training needs developed earlier, list concerns about realistically meeting the stated objective.*

Activity 3.1

Determining Training Needs

Purpose

To identify the allowable activities and future training needs associated with meeting a stated agency policy.

Directions

1. You will be assigned to small groups.

2. Your chief officer has asked you to look at two issues related to the following change in agency policy.

   All emergency medical personnel will support all hazardous materials incident responses.

   The two issues are permissible activities and required training for hazardous materials response.

3. Develop the following two lists: the activities you now are allowed to perform consistent with your current level of training; and future training needs to fulfill the new agency policy **realistically**.

Allowable Activities

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Future Training Needs

Activity 3.2

Identifying Realistic Concerns

Purpose

To identify the real concerns stemming from the challenges placed on responders by the training requirements associated with meeting the stated policy in the local plan.

Directions

1. Work alone or with someone from your department.

2. You respond in a basic life support ambulance to a reported medical emergency. Upon arrival, you determine that it is actually a hazardous materials incident. The only other responder present is a police officer who arrived in his/her patrol car.

3. On the basis of the previous activity (the list of activities you can perform and your agency's limitations), list your real concerns in providing emergency medical service at this incident.

Concerns

STANDARD OF CARE (SOC)

Chemicals truly have become an integral part of our lives. There are many reasons for this, from the depletion of raw materials forcing us to look to synthetics to the urging of the fire service to build more fire-resistant structures. As our population continues to grow and even outpaces our natural resources, the role of synthetics and chemicals in our lives can only increase.

For the emergency responder, this is not a philosophical argument over whether this development is good or bad; it is a matter of reality that we will be responding to chemical events as long as we have human error and mechanical failures. It does not take a lot of forethought to see that, in order to keep pace with the problems posed by hazardous materials incidents, emergency responders' levels of expertise must increase accordingly to deal safely and effectively with the problem. And the problem is growing.

In 1965, the total number of chemicals registered by the Chemical Abstract Service was about 212,000. In 1988, this number had grown to 9.3 million. This represents roughly a 43-fold increase in just 24 years! Broken down into more manageable numbers, this means an average annual increase of about 387,000!

Along with this explosion of chemicals, a number of lessons have been learned that point out the need for appropriate response to hazardous materials emergencies. The potential impacts of a hazardous materials emergency can be devastating. We all can recall that horrid day in Bhopal, India, when 2,500 to 3,000 people died a short time after a release of methyl isocyanate. This does not include the people who will suffer and die an early death as a result of this release; they could number up to a third of a million or more. Incidents such as those that occurred at Waverly, Tennessee, and Kingman, Arizona, also point out the potentially devastating nature of uncontrolled hazardous materials.

An Enlightened Response

It is hoped that other lessons have stuck with us. It is now known that operational approaches also can affect the outcome of a hazardous materials incident. It is easy to play Monday-morning quarterback, but almost anyone can recall an incident where the outcome would have been more favorable had a more enlightened approach been taken. Here lies the key to safe and effective operations: an enlightened response.

Responders to hazardous materials emergencies need certain skills and knowledge for handling these incidents. As time passes and responders receive more guidance and training, and as consensus standards are developed, higher expectations for the delivery of safe and qualified services when responding to such incidents arise. We can call these expectations "the hazardous materials SOC."

Hazardous Materials SOC

An SOC probably is best described as "…the level of competency anticipated or mandated in the performance of a service or duty." In other words, an SOC is a yardstick by which someone, like emergency responders, will be measured if their actions in a given situation are questioned.

There are many factors that help determine what the SOC actually is. These are called the influences on the SOC.

Factors Influencing the SOC

First, there are the federal laws that usually result in the promulgation of regulations to give the law teeth. Guidance documents published by the federal government to help interpret the regulations also play a role.

Another influence is the consensus standard. These standards are developed by the industry or trade to which the SOC applies. In the fire service, these standards generally are published by the NFPA. But the NFPA is not the only standard-setting organization. Other important bases of the SOC are the experience and knowledge of all who respond to these types of incidents. In addition, there are the experts and specialists in allied professions who contribute to the body of knowledge. For example, two relevant disciplines are toxicology and industrial hygiene. A SOC, however subjective it may seem, is of paramount importance. This also is true in emergency response.

Related to the SOC are some legal implications. If there is a standard, what happens to the person who violates that standard? Our legal system deals with these matters. We need to take a brief look at some of the basic concepts lawyers and the courts use to deal with the issue. We will examine five of these concepts.

Legal Implications

Emergency response personnel, just by showing up to work, assume a certain amount of liability. To be liable means to owe a responsibility or duty. Since the very nature of emergency response jobs involves service and duty, it is a given that responders are constantly liable. One cannot escape this in emergency services. There is an understood liability to perform to the prevailing SOC. To operate outside the SOC or in ignorance of it is to play Russian roulette, not only with the lives and property of others, but with one's own career and life as well.

Negligence

Negligence is defined as operating outside the SOC. Generally speaking, there are three conditions one must prove before one can prove "negligence": 1) there is a duty to act; 2) one operates outside the SOC; and 3) someone incurs a loss as a result of operating outside the SOC. An individual firefighter, an officer, or the organization can be found guilty of negligence, even unintentional. This becomes even more serious when the SOC was violated intentionally.

Gross Negligence

When there is willful violation of the SOC, gross negligence is said to have occurred. For example, an emergency medical technician is treating a patient. The technician begins to sense with a high degree of suspicion that the patient may have a spinal injury, but the technician does not immobilize the patient. His/Her reason was that it was raining and he/she wanted to get to the apparatus. This would be an example of gross negligence and could be costly if the patient suffered additional injury or died as a result of the responder's intentional negligence.

Another example of gross negligence would be a decision by a fire chief not to conduct training required by regulation because there is not enough money in the budget. Generally, it is less expensive in the long run to appropriate the funding necessary to meet the SOC. Litigation can be very expensive; judgments could cost millions.

Malfeasance

The next term that is associated with a public official's or public servant's failure to act properly is malfeasance: willful misconduct or intentional harm to others. It is conduct that is a serious departure from ordinary care and often is considered to be unreasonable.

Charges of malfeasance involve intentional actions to harm others; these charges usually are brought under state criminal provisions.

Another term that has been around for a long time is sovereign immunity.

Sovereign Immunity

Sovereign immunity means that individuals harmed by the action of a governmental unit, or someone officially representing that unit, cannot recover damages from that governmental unit unless the government agrees to pay the claim.

This concept is changing. In the past 30 years, more and more states have reduced their claim to sovereign immunity. States usually keep some claim to it through laws such as the state emergency management act or some other public safety provisions.

Thus, emergency responders, as public servants, may be protected under the umbrella of the state's immunity provisions. However, this immunity can be jeopardized if one acts out of gross negligence or malfeasance.

As mentioned earlier, many factors influence the SOC for any service. When it comes to hazardous materials response, we need to look at some specific laws, regulations, and standards that influence delivery of service. Let's begin with federal laws.

Federal Laws

Three major federal laws have a direct influence on the SOC. Laws are enacted by Congress and sometimes tend to be very broad and nonspecific in nature. They frequently give birth to regulations written by specific agencies charged with the responsibility for carrying out the law.

The first major "hazardous materials" law is the **Clean Water Act of 1970 (CWA)**. Many say it was a response to a major accident that resulted in an oil spill seven times larger than that of the Exxon *Valdez.* Regardless of why it was written, the **CWA** defined a federal role in response to oil spills. This law and its subsequent regulations established the National

Contingency Plan and created the National Response Center to coordinate efforts at a major release. The National Response Team also resulted from this enactment.

In 1980, the **Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)** (or Superfund Act) was passed, and broadened the role of the federal government in response to chemical emergencies. This act resulted in response to more types of chemicals, allotted funding for the response in certain instances, and included not just accidents in shipping lanes, but in tributaries and on land.

In 1986, the **Superfund Amendments and Reauthorization Act (SARA)** was passed; this has had probably the most comprehensive effect on hazardous materials response of any law. SARA was written to amend and reauthorize CERCLA. Although a major focus of SARA dealt with waste cleanup, it also had an impact on other areas as well.

SARA established requirements for planning, response, management, and training for response to chemical emergencies. This law mandated that OSHA establish training requirements for emergency response personnel. SARA also required the establishment of state and local planning groups to develop response plans for state and local jurisdictions. For these laws to have an impact, and to allow for enforcement, specific federal agencies had to write regulations.

Federal Regulations

Regulations written at the federal (and state) level play a tremendous role in helping to formulate the hazardous materials SOC. Regulations are mandatory standards backed up by their corresponding laws. Regulations written at the federal level are published by the government and become part of the **Code of Federal Regulations (CFR)**. The CFR is broken into 50 sections called titles that are amended on a regular basis. We need to look at the regulations that directly affect hazardous materials response.

EPA 40 CFR 300

The Environmental Protection Agency (EPA) wrote 40 CFR 300, **The National Oil and Hazardous Substance Contingency Plan**, or NCP. This regulation created the National Response Team (NRT), called for the formation of Regional Response Teams (RRTs) and predesignated a Federal On-Scene Coordinator (OSC). This coordinator may or may not respond to the incident site, but regardless of his/her location, the coordinator may authorize the release of huge federal resources to deal with a major incident. This OSC generally will be a member of the EPA or the United States Coast Guard, depending on the location of the incident. The effect of this regulation has been a serious attempt at a coordinated response among federal, state, and local governments.

OSHA 29 CFR 1910.120

These regulations deal more directly with the way local response will be carried out. The Occupational Safety and Health Administration's (OSHA) 29 CFR 1910.120 and EPA 40 CFR 311 are identical regulations mandated by SARA. The reason for the duplication is to ensure coverage of all responders, in both OSHA and non-OSHA states. While many of the provisions of these regulations cover waste-site operations, emergency response also is addressed.

The final portion of these rules deals with the regulation of hazardous materials emergencies. It covers many important concepts. The illustration below summarizes the key parts of this regulation.

Key Parts of OSHA 29 CFR 1910.120 (EPA 40 CFR 311)

Definition of emergency response
Organization of work groups
Definition of hazardous materials response teams
Health hazard considerations
Medical monitoring and physical examinations
Emergency response plans
Incident management
Role of the safety officer
Protective clothing requirements
Operational procedures and emergency medical response
Competency-based training

Competency-Based Training

The competency-based training referenced in the regulation deals with the five levels of training with which all emergency responders are probably familiar. We need to look at them in some detail.

First Responder Awareness Level

OSHA defines persons at this level as

> individuals who are likely to witness or discover a hazardous substance release and who have been trained to initiate an emergency response sequence by notifying the proper authorities of the release. They would take no further action beyond notifying the authorities of the release. First responders at the awareness level shall have sufficient training or have had sufficient experience to objectively demonstrate competency in the following areas (q)(6)(i).

The regulation then lists these competencies:

- Understand what hazardous substances are, and the risks associated with them in an incident.
- Understand the potential outcomes associated with an emergency created when hazardous substances are present.
- Recognize the presence of hazardous substances in an emergency.
- Identify the hazardous substances, if possible.
- Understand the role of the first responder awareness individual in the employer's emergency response plan, including site security and control and the U.S. Department of Transportation's *Emergency Response Guidebook.*
- Realize the need for additional resources, and to make appropriate notifications to the communication center.

First Responder Operations Level

Operations-Level first responders

> are individuals who respond to releases or potential releases of hazardous substances as part of the initial response for the purpose of protecting nearby persons, property, or the environment from the effects of the release. They are trained to respond in a defensive fashion without actually trying to stop the release. Their function is to contain the release from a safe distance, keep it from spreading, and prevent exposures (q)(6)(ii).

The regulation goes on to say that first responders at the Operations Level shall have had at least eight hours of training or possess sufficient experience to demonstrate competency in the various areas listed below. This is in addition to the competencies listed for the Awareness Level. Furthermore, the responders' employer is responsible for certifying the following competencies:

- Know basic hazard and risk assessment techniques.
- Know how to select and use proper personal protective equipment (PPE) provided to the first responder Operations Level.
- Understand basic hazardous materials terms.
- Know how to perform basic control, containment, and/or confinement operations within the capabilities of the resources and PPE available with their unit.
- Know how to implement basic decontamination procedures.
- Understand the relevant standard operating procedures (SOPs) and termination procedures.

The regulation continues with similar details for three other levels. Since these three are beyond the scope of this course, we will mention them much more briefly.

Hazardous Materials Technician

Hazardous materials technicians are responders whose job is to stop the release. They are more aggressive than a first responder at the Operations Level. They will approach the point of release in order to plug, patch, or otherwise stop the release of a hazardous substance.

They receive at least 24 hours of training equal to the first responder at the Operations Level; they also will have competency in 9 other areas.

Hazardous Materials Specialist

Hazardous materials specialists respond with and support the hazardous materials technicians. Their duties parallel those of the technician, but require a more specific knowledge of the various substances they may be called upon to contain.

The hazardous materials specialist also would act as the site liaison with federal, state, local, and other government authorities in regard to site activities.

Like the other 3 levels, this level has its own training requirements (a minimum of 24 hours equivalent to the technician level) and a set of 9 competencies.

On-Scene Incident Commander

Finally, there is the Incident Commander (IC) level. Training for the commander is less demanding than for the technician or specialist. It requires at least 24 hours equal to the first responder at the operations level; there are 6 additional competencies.

Additional Regulations

Additional key regulations include 49 CFR 100-199, dealing with the transportation of hazardous materials. Items covered include classification of hazardous materials in transportation, container requirements, cargo compatibilities, placarding and labeling requirements, shipping papers, and myriad other transportation issues. 49 CFR 100-199 is the primary enforcement tool used when dealing with the transportation of hazardous materials.

In addition to the federal laws and regulations, another important contributor to the SOC is consensus standards.

Consensus Standards

Although laws and regulations are, in fact, types of mandatory governmental standards, there are other types of standards that influence the hazardous materials SOC. These are called consensus standards.

Many professions and industries have organizations or groups made up of various representatives from that industry that meet in order to decide essentially how that industry or profession will conduct business. When this occurs, the group has provided a consensus concerning the "right" way to do something. Because a "consensus" has been reached within the industry, these agreements can carry considerable weight in any litigation that may occur concerning that particular industry or profession.

NFPA Standards

In the fire and emergency services fields, an important standard-writing body is the National Fire Protection Association (NFPA). It is not the only one, however.

The NFPA has produced standards on responding to hazardous materials incidents that closely follow, and in some instances exceed, the regulations written by the government. Currently three standards relate directly to response to hazardous materials incidents: NFPA 471, 472, and 473. All were produced by the NFPA Technical Committee on Hazardous Materials.

NFPA 471

This standard deals with recommended practices for responding to hazardous materials incidents. It applies to all responders and outlines such considerations as incident response planning, response levels, control options, PPE, decontamination, and safety and communications.

NFPA 472

This standard addresses competencies for responders. It is a good comprehensive guide to specific knowledge and competencies required to respond safely to hazardous materials incidents. In theory, any training program that meets the objectives in this standard are in compliance with the applicable federal regulations.

NFPA 473

Emergency medical services response to hazardous materials incidents is the focus of NFPA 473. This standard addresses specific competencies needed by emergency medical personnel to respond to chemical emergencies and to treat victims at these emergencies.

We will return to some of this information later in this unit.

Guidance Documents

Guidance documents and other federal, state, and private programs also provide direction to the hazardous materials SOC. Operational guidelines of individual agencies, for instance, fire departments' SOPs, also play a part. These SOPs should be integrated into local and regional plans that, in turn, provide an additional influence on the SOC in that jurisdiction. Some of the federal regulations talked about earlier require this integration of operational approaches and local response plans.

Role of Toxicology

Perhaps one of the most important influences on the SOC in the hazardous materials business is the field of toxicology, the science that studies toxins and their effects on the body. Related to toxicology is industrial hygiene, which is an application of the science to the workplace. Hazardous materials operations is a further extension of both.

Thus toxicology and its two related fields also influence the SOC. Many of the hazardous materials response procedures in use today are nothing more than the extension of the practice of good industrial hygiene. Work practices that prevent or minimize contamination, engineering controls, monitoring, and proper use of protective equipment are all components of a "clean" workplace. The objective of industrial hygiene is this "clean" workplace.

The most important goal in emergency response to hazardous materials incidents is to prevent harm to people, to property, to the environment, and to critical systems. This course focuses on the harmful event as it relates to people. The "toxic event" is one important mechanism by which people can be harmed. To understand, respond to, and prevent as much as possible the "toxic event," it is helpful to have a working knowledge of some of the basic concepts of toxicology.

The Need for Training in Toxicology

There are many reasons to justify the time and money spent on training, among them legal requirements, the SOC, and the very mission of most emergency response agencies. An improper response to any emergency (or a proper response, for that matter) can lead to litigation. The best defense against negative judgments is a proper response. When it can be shown that a fire department or other agency personnel did not follow the laws and regulations or did not have the required training, and some harm occurred as a result, the department or the agency may be liable.

Once laws and regulations are passed that require something to be done a certain way, it becomes a cost of doing business to do it that way. Some complain that training is too costly and time-consuming. Those who believe that should compare the hourly cost of a team of lawyers to that of a competent fire service instructor; classroom costs generally are lower than court costs, too. Sometimes jury awards run into the millions of dollars. More important than money are other concerns, such as human life.

Increased Hazardous Materials Role Challenges Tradition

The emergency services field is rich in tradition. Sometimes these traditions can block progress, but in some ways they are wonderful things. The tradition of unselfish service has, and will continue to be, the life-blood of emergency services units. The protection of life and property has been an almost universal mission statement in this service for a long time.

Emergency response units, whether fire, police, or medical, are increasingly involved in chemical incident mitigation. Some of the many reasons were covered earlier. But the fact is that more and more routine responses involve hazardous materials. This can be true of the simplest call to a house fire or to an automobile collision.

This is primarily why NFPA 472 and 473 have several sections that relate to toxicology.

Toxicology Requirements in NFPA 472 and 473

The following information is a synopsis of the toxicological suggestions or guidance in NFPA 472 and 473 and is not meant to be a substitute for those documents. As stated earlier, we are dealing with recommendations and not regulations: these recommendations are helpful and contribute to the SOC.

Therefore, they should not be dismissed arbitrarily as unimportant. Rather, emergency responders who are trying to assure that they are operating in the safest and most efficient manner will try to model their behavior on these recommendations.

Specifically in reference to toxicology, NFPA suggests that hazardous materials responders be competent to do the following.

Basic Competencies

- Identify ways that hazardous materials can harm people.
- Identify the routes of entry for hazardous materials.
- Identify precautions for treating persons injured by hazardous materials.
- Given a Material Safety Data Sheet (MSDS), identify the health hazards, signs and symptoms, routes of entry, permissible exposure limits (PELs), and first aid measures.
- Differentiate between exposure and hazard, exposure and contamination, and direct and secondary contamination.
- Identify the health hazards of asphyxiants, irritants and corrosives, sensitizers and allergens, convulsants, and chronic health hazards.
- Identify the need for and the procedures for emergency decontamination.
- Identify the signs and symptoms of heat and cold stress.

These are basic competencies. The technician has others.

Competencies for Technicians

In addition to possessing all the competencies at the Operations Level, the technician will have mastered the following.

- Given appropriate references, identify signs, symptoms, and target organs.
- Given concentrations of a released material, determine health hazards present in the hot zone.

- State the significance of the following terms:

  - IDLH--Immediately Dangerous to Life and Health
  - LC_{50}--Lethal Concentration Fifty
  - LD_{50}--Lethal Dose Fifty
  - PEL--Permissible Exposure Limit
  - TLV/C--Threshold Limit Value/Ceiling
  - TLV/STEL--Threshold Limit Value/Short-term Exposure Level
  - TLV/TWA--Threshold Limit Value/Time-weighted Average
  - PPM--Parts per Million

Additional Requirements of NFPA 473

NFPA 473, *Standard for Competencies of EMS Personnel Responding to Hazardous Materials Incidents*, is intended to offer minimum competencies for emergency medical services personnel who respond to hazardous materials emergencies. These competencies include the following.

- Identify how to access poison control centers; medical control; MSDSs; reference books; databases; technical information centers/specialists; the Agency for Toxic Substance and Disease Registry (ATSDR).

- Relate the following to assessment and treatment: acute/delayed toxicity; routes of exposure; local/systemic effects; dose/response relationship; synergism; health hazards as determined by assessing dose, toxicity, and exposure.

- Describe how contamination of patients alters the principles of triage.

- Describe the local agency's SOPs for the medical management of the chemically injured.

- Describe how contamination alters assessment and treatment of patients.

- List signs and symptoms and describe treatment protocols for corrosives, pulmonary irritants, pesticides, chemical asphyxiants, and hydrocarbon solvents.

- Identify the capabilities of local hospitals to accept hazardous materials patients.

- Explain the special hazards associated with air transportation of hazardous materials patients.

- List and explain the components of pre- and postentry assessments.

- Explain the following factors and how they influence heat stress: hydration; physical fitness; environmental factors; activity levels; level of PPE; and duration of entry.

- Demonstrate medical monitoring procedures for personnel at a hazardous materials incident.

This is quite a lot; altogether there are more than 20 items, many with subitems. It is true that many of the objectives already are well within the realm of an experienced emergency medical technician. Some of the information is familiar, and some of it may be completely new. Local jurisdiction specificity is apparent in a few of the objectives, but most of the information has universal application.

A Challenge

Many of these objectives will be covered in greater detail in the remainder of this course; it is hoped that it will build an exceptionally strong foundation for becoming a top-shelf hazardous materials emergency medical responder. However, no amount of printed materials alone will make anyone compliant with any standard.

One needs to translate into practice what is learned. One needs to have the proper attitude and openness of mind. More and more, any response to the simplest medical emergency may prove to be fraught with hazardous materials implications.

The responders who wish to protect themselves as well as their colleagues while saving the victim--if that is reasonably possible--cannot ignore the regulations and standards that now affect the emergency response service.

UNIT 4:
GENERAL PRINCIPLES OF TOXICOLOGY

OBJECTIVES

The students will be able to:

1. *Working individually, differentiate between toxins and poisons.*
2. *Given a list of alternatives and working individually, identify*
   1. *The four routes of exposure.*
   2. *Six dose-level term definitions.*
   3. *Four chemical factor definitions for influences on toxicity.*
3. *Working alone, correctly explain the dose-response relationship.*

Activity 4.1

Identifying Target Organs, Routes of Entry, and Other Bodily Functions

Purpose

To identify the target organs, routes of entry, and other bodily functions which selected chemicals are likely to attack. This information on the chemicals will be found on various MSDSs.

Directions

1. The class will be divided into small groups.
2. Use the MSDSs given to your group to locate information on the products assigned to your group.
3. Identify the likely target organ(s), the routes of entry, and any other concerns you have.

Product	Target Organ(s)	Route(s) of Entry	Other Concerns

TOXICOLOGY

Toxicology is the science that studies the effects of poisons on the human body. It also is defined as the science of poisons, dealing with their detection, their effects, and their antidotes. Toxicity is the ability of a substance to cause injury to biological tissue. This injury can result from a number of different types of toxins, which fall into categories related to the organ or system that they predominantly affect.

This is important knowledge for the emergency medical responder. A good understanding of toxicology will help responders and the persons with whom they deal from getting poisoned, knowing when they are poisoned, and deciding what to do if they are poisoned.

Effects of Toxins

Class	**Target Organ or System**
Hemotoxins	Circulatory system
Cytotoxins	Cellular metabolism
Neurotoxins	Nervous system
Necrotics	Biological tissue
Asphyxiants	Respiratory system

Poisons or toxins usually are classed as local or systemic, depending on their effects. Local toxins generally will cause immediate damage to the body area they contact, be that the skin, the respiratory tract, the gastrointestinal tract, the eyes, etc. The type and the intensity of the effect may differ from area to area on the body, but the general principle is that local toxins "hurt you where they touch you."

Conversely, systemic toxins may very well cause little or no discomfort or visible damage at the site of entry or point of contact with the body. Instead, these toxins do their damage in another manner: they affect a whole system, such as the respiratory system or the circulatory system.

This is probably a good time to try to differentiate between "toxic" and "poisonous." (The dictionary uses them synonymously.) One difference between something toxic and something poisonous is that almost anything can have "toxic" effects if taken in large enough doses. Items generally considered as poisons can cause "toxic" effects even in small doses, sometimes in very small doses. Someone has said that all things are toxic; it is only a matter of dose. More important, however, are the routes of exposure.

Routes of Exposure

The routes of exposure are the pathways the poison touches or uses to enter the body. They have a direct relationship to the severity and type of effects. A toxin spilled on the skin may be a mild irritant, but that same material may cause massive destruction to the gastrointestinal tract or the respiratory system. It is generally accepted that injection is the quickest way to the bloodstream, with inhalation being a close second.

Sometimes a person may be exposed to a toxin by a single route, such as ingestion. There are other instances where exposure or poisoning may occur through multiple routes. If a large amount of an organophosphate insecticide comes into contact with a person's skin, especially on the upper body, common sense would indicate that an inhalation injury also could occur from the vapors. We need to keep in mind that all liquids and some solids always are producing fumes. We will discuss the specific mechanisms associated with the routes of exposure in greater detail later.

Four Routes of Exposure

Inhalation

Ingestion

Absorption

Injection

Detoxification

Also related to severity and type of effect is the body's ability to detoxify itself and excrete or eliminate a toxin. If the body is able to excrete or eliminate at a rate as fast as, or faster than a toxin is being absorbed, the toxic effects generally will be minimized. Take consumption of alcohol as an example. A 110-Kg (about 242 pounds) human could ingest a teaspoonful of Bourbon whiskey every two hours for an extended period with no manifestation of toxicity. The body would be metabolizing the ethanol faster than it is being ingested, so there is no presentation of toxicity, i.e., no "buzz." On the other hand, someone who has become sick from too much alcohol and vomits has exceeded the body's ability to metabolize the alcohol. As a result there is a remarkable presentation of toxicity.

We need to keep in mind that some agents, such as cyanide and phosphine, never will be metabolized quickly enough to prevent injury. Additionally, many chemicals will do damage without regard to the body's ability to excrete. Examples would include corrosives, other local toxins, radioactivity, and etiologic agents. The concern here is the body's ability to defend itself through other mechanisms.

Mechanisms of Elimination

The body excretes or eliminates in four basic ways.

Exhalation

The exhalation phase of respiration is critical to the process of elimination. If everything is as it should be, respiration is an ongoing, automatic process. We are continually "blowing off" carbon dioxide and water vapor, which helps the body maintain a proper pH level and a healthy temperature. Let's try a simplified explanation.

Carbon dioxide gets from the bloodstream to the alveolar space in the lungs through diffusion due to gradients in partial pressure. Simply put, when a gas is dissolved within a liquid, it exerts a certain amount of "pressure." When the liquid comes into contact with a medium where the "pressure" of that gas is less, the gas will diffuse to the degree allowed by the barrier it must cross. It will continue to diffuse until equilibrium is reached. When a chemical is dissolved in the bloodstream, it will exert a "pressure" and will diffuse into the alveolar space where it can be "blown off" in the same manner as carbon dioxide.

Another consideration is the diffusion capacity of the gas across the pulmonary membrane. Some gases diffuse more readily than others; carbon dioxide has a diffusion capacity 20 times that of oxygen. Other gases will vary as well.

Perspiration

As we all know, sweat is a fluid whose primary function is temperature regulation. But since it is a fluid, many toxins can end up in perspiration, depending on solubility, polarity, and movement from one fluid compartment to another. There will be further discussion of fluids later in the course.

Urination

Many tend to think of the kidneys and urination as merely a means by which the body rids itself of wastes. In fact, the function of the kidneys is critical to homeostasis and life itself. Homeostasis is the physiological balance between functions and the chemical composition with an organism. Electrolytes are kept in balance, fluid levels are maintained throughout the body, pH is regulated, and other important functions are performed by the kidneys. One of these important functions is the removal of organic toxins and other dangerous substances. Also consider that many toxins are metabolized in other parts of the body and transported to the kidneys for excretion as harmless metabolic byproducts.

Defecation

What is really happening here is not so much excretion as it is elimination. The feces are made up mostly of waste from the body such as dead cells and other tissue, and food that was not processed by the body. At this point, we need to make a distinction between excretion and elimination.

Elimination deals with the body getting rid of ingested materials that have not been absorbed and metabolized by the body. Excretion is the expulsion of metabolic byproducts; in other words excretion is what is left over after the body has done what it is going to do with something.

Since excretion implies that a substance has been acted on by the body, it is clear that it would be better to eliminate toxic substances as opposed to excreting them. This is one of the driving principles behind inducing emesis, gastric lavage, and the use of cathartics. One of the only true types of "excretion" going on in the intestine is the excretion of bile pigments. The excretory mechanisms are capable of elimination in some instances.

One organ that has not been mentioned is the liver. The liver does not truly excrete or eliminate substances, but rather metabolizes them and discharges wastes from that metabolism. The wastes are then excreted through one of the other mechanisms.

Some chemicals may be eliminated very quickly and others may take a long time. The body continually reabsorbs some chemicals, which can remain for a lifetime. The amount of a toxic material remaining in the body is referred to as the body burden.

This brief discussion of elimination and excretion is somewhat academic for the emergency responder, but it does raise some important points.

First of all, consideration must be given to enhancing elimination or excretion, if indicated. Second, responders must protect themselves against the possibility of exposure to the products resulting from the above-mentioned mechanisms. Even though some toxins may be acted upon by the body, the metabolic byproducts also could be harmful. In other instances, the poison still may be in its original state just waiting for another chance to inflict harm on the unsuspecting or less careful responder.

Dose-Response Relationship

Contacting a hazardous material quite often will result in some type of harm as a result of interference with or destruction of individual cells within the body. The ability of a chemical to cause harm is referred to as its toxicity. There is a relationship between the dose of a toxic material and the biological response that occurs. As we will learn later, there are many factors that can influence toxicity. All other factors being equal, the biological response, in both type and intensity, to a given dose of a chemical is referred to as the dose-response relationship. In a nutshell, the dose-response relationship is a quantitative relationship between the dose of a chemical and an effect caused by the chemical. The period of time over which a dose is administered is usually specified when referencing the dose-response relationship. This is important.

Dosage usually is measured in one of the following three ways:

1. Mg/Kg or quantity versus body weight.
2. Mg/cm^3 or quantity per unit area of skin surface.
3. PPM or mg/m^3.

There are certain terms that specify the dose-response relationship. These terms most often are used in controlled situations where exact chemical concentrations are known or can be controlled. In the emergency response world, the situation often is uncontrolled. That is why the emergency response took place. Furthermore, field monitoring equipment cannot always determine exact concentrations. So, in the field, setting these terms becomes more of a *gauge of relative toxicity*. This will assist with decisions that have to be made concerning operational approach, levels of protection, decontamination, evacuation needs, and other important concerns.

These terms are defined by different agencies and some of them may be similar or identical. In fact some of them are used by more than one agency. Some of the ones most commonly used, with a brief definition of each, are given below.

Toxic Dose Low--TDLO (NIOSH)

The lowest dose of a substance introduced by any route, other than inhalation, over any given period of time, reported to produce any toxic effect in humans or to produce tumorigenic or reproductive effects in animals.

Toxic Concentration Low--TCLO (NIOSH)

This is the same as above except this value deals with concentrations in air and inhalation.

Lethal Dose Low--LDLO (NIOSH)

The lowest dose of a substance introduced by any route, other than inhalation, which has been reported to have caused death in humans or animals.

Lethal Concentration Low--LCLO (NIOSH)

This is the same as above, except this value deals with concentrations in air and inhalation.

Lethal Dose Fifty--LD_{50} (NIOSH)

A calculated dose of a substance which is expected to cause death in 50 percent of an entire defined experimental animal population.

Lethal Concentration Fifty--LC_{50} (NIOSH)

A calculated concentration of a substance in air, exposure to which for a specified length of time is expected to cause the death of 50 percent of an entire experimental animal population.

Permissible Exposure Limit--PEL (OSHA)

The maximum average concentration (averaged over 8 continuous hours) to which 95 percent of otherwise healthy adults can be repeatedly and safely exposed for periods of 8 hours per day, 40 hours per week.

Threshold Limit Value/Time-Weighted Average--TLV/TWA ACGIH)

The maximum average concentration (averaged over 8 continuous hours) to which an otherwise healthy adult can be repeatedly and safely exposed for periods of 8 hours per day, 40 hours per week. This value is similar in concept to the PEL.

Threshold Limit Value/Short-Term Exposure Limit--TLV/STEL (ACGIH)

The maximum average concentration to which an otherwise healthy adult can safely be exposed for up to 15 minutes continuously. Workers should not be exposed to this level more than 4 times per day with at least 60 minutes between each exposure.

Immediately Dangerous to Life and Health--IDLH (OSHA and NIOSH)

That concentration that poses an immediate danger to the life or health of a person exposed, but from which the person could escape without any escape-impairing symptoms or irreversible health effects. Concentrations above this amount will cause life or health risks and impair the ability to escape.

Threshold Limit Value--Ceiling--TLV-C (ACGIH)

The maximum concentration to which a healthy adult can be exposed without injury.

Factors Influencing Toxicity

We have discussed the relationship between dose and response, but there are other factors to be considered when attempting to estimate the potential for toxic injury. The specific response elicited by a given dose of a chemical is dependent on the species being tested and other variations that can occur within the same species. Here are the factors that influence toxicity:

- duration and frequency of exposure;
- route of entry;
- interspecies variation;

  This means the reaction of one type of animal may be very different from that of another animal or a human. Every effort is made to closely approximate human physiology and response when conducting tests with animals.

- intraspecies variations;

  These are age and maturity, gender and hormonal status, genetic makeup, and overall state of health.

- environmental factors; and
- chemical combinations.

Synergism

Synergism occurs when two chemicals react to create a greater than additive effect. Using mathematical symbols, this might be expressed as $1 + 1 = 3$.

Potentiation

Potentiation is similar to synergism except that one of the chemicals is usually not toxic. When added to a potentiator, it produces a toxic effect. Again, in mathematical symbols, $1 + 0 = 3$.

Antagonism

Antagonism occurs when a mixture of chemicals produces a less-than-anticipated additive effect. Narcan® is an example of an antagonist. Another is ethanol (the kind of alcohol that can be drunk) used to treat poisoning with methanol. Methanol is highly toxic because it metabolizes to formaldehyde and then to formic acid, neither of which is compatible with good health. If methanol is ingested, ethanol can be administered. When both are present, the ethanol will be preferentially metabolized while the unaltered methanol is excreted. Of course, the ethanol will metabolize to acetaldehyde, but all that does is cause a hangover, which is generally preferable to blindness or death.

Another type of antagonist is Antabuse® (disulfuram). It is given in alcohol aversion therapy to attempt to keep alcoholics from drinking. It blocks the metabolism of acetaldehyde to acetic acid causing sickness and a prolonged, intensified hangover. With enough alcohol it can be life-threatening.

Antagonism will be an important part of our later discussion on care for victims of poisoning.

SUMMARY

Emergency responders who have even a basic understanding of toxicology will have a great advantage over those who do not. The responders who wish to act safely and protect not only their lives but those of the victims they assist will be better equipped to do so because of their grasp of toxicology. Appreciating in a general manner the potential hazards issuing from hazardous substances is one thing. Knowing specifically what these hazardous substances can do to the human body is better. This is what this course on toxicology is all about. The following units will discuss this in greater detail.

UNIT 5:
ONSITE MEDICAL SURVEILLANCE

OBJECTIVES

Given a list of alternatives and working individually, the students will be able to identify

1. *Four vital signs used for assessing responders' conditions.*
2. *Two times when responders' conditions should be assessed.*
3. *Three symptoms of heat exhaustion and recommended treatment.*
4. *Five symptoms of heat stroke and recommended treatment.*
5. *Three vital signs that indicate the need for a rest period.*

EMERGENCY MEDICAL SERVICES

For our purposes we will call emergency medical services those functions that emergency medical service personnel perform at a hazardous materials incident. The primary and secondary areas of responsibility for this medical service are

- pre- and postentry vital sign monitoring for all members of the entry and backup teams; and
- assessment, stabilization, and transport of injured and/or contaminated civilians and response personnel.

MONITORING VITAL SIGNS

Monitoring the vital signs of the entry and backup teams is an important step both before they enter the exclusion zone and after they leave it. The vital signs are the usual ones: pulse, blood pressure, and body temperature. Weight and EKG readings are not essential.

A good standard operating procedure is to use a ready-made form that records these data and allows for a quick comparison of pre- and postentry readings. This same form could record various other bits of information, such as meteorological data, communications times, operational versus standby times, etc. It also could indicate required recuperative periods. It could note unusual circumstances that provide additional physical or emotional stress, such as "downed" civilians or response personnel requiring aid and/or hospitalization. All these data might be useful in developing a Standard of Care (SOC) for similar types of operations.

During an incident, the vital signs data will be used to assess the effects of being suited on operational forces. Specifically, the chart records will provide a means to assess heat stress, dehydration, and exposure. It will help to determine the need for and duration of recuperative periods.

When operations are completed, this chart should become part of each team member's permanent incident history record file.

HEAT-RELATED EMERGENCIES

A well-functioning body balances the need for warmth and cooling by alerting us to one or the other. If exposed to excessive external heat, or if our body's internal temperature rises too much, we **must** sweat. Some of us do so more easily than others. To be overheated and not to sweat at all can lead to serious injury and perhaps death. We cannot go to the other extreme either, because sweating profusely, if one does not compensate for it, will lead to dehydration.

Where such severe dehydration has occurred, the body may suffer a complete breakdown of its cooling system. We are a walking, talking, breathing, and appropriately balanced composite of chemical elements and water. The loss of enough liquid will cause a hypovolemic (low volume) blood condition and salt loss. Salt, when dissolved in our body's liquids, functions as an ionic conductor or electrolyte and assists in maintaining the body's electrical and message-sending systems. When those systems do not work efficiently, serious things begin to happen. One of these is cardiac arrhythmia, a change in either the beat or the force (or both) of the heart's motion.

Heat stress ranges from a minor irritation to a life-threatening situation. We need to look at the more common manifestations of heat stress.

Heat Rash

This first is but a minor irritation to the skin, commonly called "prickly heat." It is often aggravated by chafing. There is no increase in the body's internal temperature, but the chafed skin surfaces can provide an excellent environment for bacterial and fungal skin infections, if the skin or garments are not clean.

Heat Cramps

These are the result of a body fluid and electrolyte loss through perspiration. When this occurs, an individual will become hypovolemic and enter the early stages of electrolyte imbalance. As the loss of salt becomes more pronounced, spasmodic contractions and pain will develop. They will occur most often in the muscles of the abdomen and extremities, but as with heat rash an abnormal increase in the body's internal temperature will **not** be observed. Other vital signs also will be found to be normal.

Heat Exhaustion (Prostration)

The next level of heat stress can produce a victim with a peripheral temperature near or slightly below normal and a rising deep-core body temperature. This would indicate a hypovolemic response. Pulse will be weak, rapid, and thready. Muscles will appear tense and may be contracting. Blood pressure will be low and respiration shallow and quiet. Pupils will be equal and reactive. Skin will be pale, cool, and moist, accompanied by profuse sweating (diaphoresis).

This condition normally is not life threatening, if treated quickly. A victim should be removed from the source of heat immediately and rehydrated with electrolyte solutions, because of the initial hypovolemic insufficiency. The victim should be place supine with the head lower than the rest of the body. Keeping the person cool by any means available is essential. If these things are not done rapidly, the heat exhaustion may proceed to the next and, potentially fatal, stage.

Heat Stroke

Heat stroke is the complete breakdown of the body's heat control system. It is a life-threatening condition and medically classified as hyperthermia. The symptoms include the following:

- red, hot and dry skin;
- body temperatures as high as 106°F to 110°F;
- fast, bounding, and strong pulse;
- elevated blood pressure;
- muscles tense, with possible convulsions; and
- equally dilated pupils.

An individual may be unconscious, unresponsive, delirious, or convulsive. Due to the hyperthermia and reduced oxygen in the blood, irreparable brain damage will result rapidly if the body's temperature is not immediately lowered.

Any means available should be used to cool a victim, while maintaining the head above the rest of the body and preparing the person for transport to a hospital. Body temperature **must** be taken about every 10 minutes and should not go **below** 101°F. Normal intravenous saline solution may be needed to rehydrate and balance electrolyte levels.

Not to be overlooked, of course, is an equally important problem of the opposite kind: cold stress.

COLD STRESS

Cold stress (hypothermia) is any situation that tends to draw heat from the body, causing varied and increasingly debilitating effects. One of the first of these effects is the loss of the individual's ability to think clearly. One fixates on the discomfort of feeling cold and tends to disregard even potentially perilous circumstances. As the heat loss continues, shivering, lack of coordination, and reduced consciousness will occur.

When body temperature drops below approximately 96°F, hypothermia results. Thereafter, the temperature can drop dramatically if one is not removed from the chilling conditions, monitored, and slowly rewarmed.

Warming techniques include placement in a warm area, blanketing, and providing warm liquids. If unconscious, the individual should be wrapped with blankets, monitored, and transported to a health-care facility.

REST AND RECUPERATION (REHABILITATION) INTERVALS

Personnel in aerobically fit condition, performing under normal working conditions for a period of 20 minutes, should require the following rest and recuperation times.

Rest and Recuperation Times

Temperature	R and R Required
<70°F	30 minutes
70 to 85°F	45 minutes
>85°F	60 minutes

During this period, personnel should be warmed or cooled as the situation may call for and as indicated by any changes in vital signs taken earlier and recorded on the operations record chart. Personnel also should take cool fluids containing electrolytes, to counteract the effects of dehydration.

At the end of the rest period, personnel should have their vital signs recorded again to ensure that all have returned to normal. Only then should members be permitted to re-enter a working environment.

When vital sign monitoring indicates something unusual, there is a need for further monitoring in order to prevent physiological complications or the effects of exposure. Should an examination indicate heat exhaustion or heat stroke, the victim should receive immediate medical help.

Because entry teams appear well protected by mountains of paraphernalia, it is easy for medical personnel to be misled into believing that nothing but a possible heat stress disorder exists.

However, it is possible something else may have occurred. Penetration, permeation, or degradation of an entry suit may have taken place, exposing operating forces to potentially tragic results. Inadequate decontamination at the scene, residue from a previous operation not properly decontaminated, faulty suit removal techniques, or cross-contamination may contribute to chemical exposure.

In fact, there have been incidents where poor decontamination procedures at a previous incident exposed wearers to chemicals not found at the scene where they fell victim. If a suit has sustained a leak as well, allowing product at the second scene to enter the suit, medical personnel could be sorely taxed. Would they be treating for symptoms of the first product, the second product, or a synergistic effect of both? This possibility points out the importance of tracking the suits, their wearers, and recorded exposures.

CONTAMINATED VICTIMS--AN EMS ROLE?

Operations involving contaminated victims are, to grossly understate the problem, challenging. Clearly, handling the ambulatory is easier than managing the unconscious and seriously injured. Quite obviously, more personnel are required to deal with the nonambulatory. But unlike the traditional fire scene with the likelihood of adequate help, the exclusion and warm zones are not exactly crowded with assistants.

The guidelines to follow are general; they are not sacrosanct and are written with the knowledge that the role of EMS personnel is, at present, an evolving one. Changes that will modify operations will occur as time goes on. Therefore, a need exists for flexibility in defining the limits of medical involvement in hazardous materials operations, to allow for that anticipated change.

Unless one's jurisdiction operates to the contrary, emergency medical personnel generally do not enter a hot zone, even on rescue efforts; the hazardous materials unit's entry team does that. However, medical staff must be appropriately trained and wear the personal protective equipment

(PPE) required, even if they enter the decontamination corridor to perform in a medical capacity only. In short, medical staff must be able to perform their functions while using Level A protective equipment.

Furthermore, having entered the decontamination corridor, medical personnel cannot leave without first being decontaminated. Consequently, a victim requiring immediate removal from one zone to another must be transferred to a clean stretcher and handled by a second medical crew not previously exposed.

Since there are definite limits to the type of equipment that may be used effectively in potentially contaminated areas, we need to consider the safety of emergency medical equipment and its ability to withstand decontamination. For example, what disaster awaits the user of an oxygen resuscitator within a reactive environment? Or, if injections could be of help but are exposed to corrosive or toxic substances, would that constitute an appropriate SOC?

When the need arises and before a victim can be transported, someone needs to identify an appropriate medical facility and notify it. Not all hospitals can or will accept contaminated victims. Locating those facilities should be part of a jurisdiction's preplanning effort. It is not something that should be hurriedly attempted during a disaster.

When the decision is made to take a victim somewhere, someone needs to tell the facility about the impending arrival. The hospital then can prepare itself. If appropriate preplanning for such an incident has been accomplished, the hospital will have much to do. Specific information about the victim's condition and vital signs will be important. So will the identity of the contaminant.

Onscene medical personnel need to package the victim in the manner discussed later in Unit 6: Decontamination During Medical Emergencies. Remove all nonessential equipment, drape the unit, and determine the need for and provide appropriate PPE for transporting personnel.

Some departments, either by purchase or through extended use, have ambulances that are no longer "serviceable." If your community or area has this option, such vehicles can be set up for contaminated victims. Nonessential equipment is removed and the vehicle is equipped with disposable equipment such as older Stokes' litters or backboards in lieu of gurneys. This is more cost-effective than contaminating a prime, expensive piece of equipment.

CONCLUSION

Emergency medical service at a hazardous materials incident can be radically different from the more typical fire or accident scene. Emergency medical personnel need to understand the differences and train in the appropriate response procedures for such emergencies.

Cooperative efforts with the hazardous materials team will be the best insurance. Together these two staffs can make the difference.

UNIT 6:
DECONTAMINATION DURING MEDICAL EMERGENCIES

OBJECTIVES

Given a list of alternatives and working individually, the students will be able to identify

1. *Two capabilities that must be part of a local hospital's decontamination response.*
2. *Five pieces of EMS decontamination equipment.*
3. *Six general guidelines for treatment of contaminated patients.*

Activity 6.1

Risk-Benefit Analysis

Purpose

To analyze a case study and to prepare you to answer similar questions in Activity 6.2 about your own department.

Directions

1. Read the following case study.

2. Within your small group, answer the questions on the worksheet. Be prepared to explain your answer to the class.

Case Study

At about 1000 hours on a Sunday the Pleasant Valley EMS unit responds to a call about a man down in the basement of a 2-story structure. The 75 by 100 foot structure is of wood construction and includes a retail store on the ground level and two apartments above.

The basic life support (BLS) unit consisting of two EMTs is greeted at the store's front door by the shopkeeper who says, "My brother-in-law was working downstairs when he fell off a ladder and broke his leg."

The crew takes the appropriate medical equipment downstairs to the basement. When the crew enters the boiler room, it sees the patient who calls out to them, obviously in great pain. It appears that the patient was working on some pipes and fell off the ladder to the concrete floor. The patient's right leg is slightly deformed with a midshaft tibia-fibula fracture bleeding moderately. The patient also is lying on some of the flat white insulation from the pipes above.

The crew questions the patient while providing proper BLS care. The crew uses universal body fluid precautions, and bandages and splints the leg. One of the crew asks the patient to describe his actions when he fell. The patient says "I was removing the insulation to repair a leaking hot water pipe. It seems that no one has done any repairs to the pipes in close to 30 years and it was ready to break."

The crew then realizes that there is possible contamination from asbestos and calls for assistance. This comes as a full response from the Pleasant Valley emergency services agency. The local law enforcement agency establishes scene control and reroutes traffic while the fire department, with the help of a hazardous materials response team, sets up a decontamination line.

The patient is decontaminated and transported by another ambulance. Afterwards, the two crew members are decontaminated and transported to the hospital for examination.

The crew members transporting the patient wear disposable coveralls and self-contained breathing apparatus for the three-minute trip to the hospital. When they arrive, hospital staff refuse to let them in, not wanting to contaminate the emergency room. A member of the haz mat response team then responds to the hospital and coordinates the acceptance of the patient, informing the staff about the possible risks.

The patient receives treatment and goes home later in the day with a cast. Environmental personnel respond to the site and confirm the presence of asbestos. A cleanup contractor is hired to remove the asbestos.

Activity 6.1 (cont'd)

Questions

1. From the dispatch information, did the responding crew know they were responding to a possible hazardous materials incident?

2. When did the crew realize this was a hazardous materials call?

3. Once the crew declared a hazardous materials incident, did the following onscene events proceed correctly?

4. Did the hospital react appropriately when the patient arrived?

5. Was the use of self-contained breathing apparatus by the transporting unit required?

6. Was there a pre-existing plan with the hospital regarding the acceptance of contaminated patients?

____

____

____

7. How could there have been better interface with the hospital?

____

____

____

Activity 6.2

Risk Versus Benefit

Purpose

To think about the risk/benefit relationship as you respond to hazardous materials incidents.

Directions

1. Insofar as you can with your current knowledge and information, think about your agency's ability to handle a hazardous materials call.

2. As you do, answer the following questions.

    a. What would your level of training allow you to do in a situation similar to that described in the case study?

    ____

    ____

    ____

    b. What equipment do you have, for which you have been trained, that you can use to protect yourself?

    ____

    ____

    ____

    c. What agency SOPs/SOGs cover this kind of incident? Have you reviewed them lately?

    ____

    ____

    ____

    d. Do you have training, equipment, and competency to perform all the tasks stated in the SOP/SOG?

    ____

    ____

    ____

e. If you tell the dispatcher that a call has become a hazardous materials call, what will the dispatcher do?

f. List the type of assistance you would need for a hazardous materials call, and its likely source(s).

g. Estimate how long it would take each type of assistance to reach you.

h. Can your hazardous materials team treat your patients properly?

i. Does your agency have a preplan with the hospital for receiving contaminated patients?

j. Does your agency have treatment protocols for contaminated patients? Do you know what they are?

k. Where would you get additional information at a hazardous materials scene?

____

____

____

l. What are the risks versus the benefits of starting immediate care as opposed to waiting for a hazardous materials team to respond?

____

____

____

THE PROTECTED RESPONDER

For the protected responder the basic minimum setup would include a tool and equipment drop, the removal or disposal of glove and boot covers, and a hand/glove wash. This would be followed by a full first washing and rinse and a second full wash and rinse. The personnel then would be desuited, using a sterile technique. The suit would be processed in whatever way the situation called for, according to written departmental SOPs. The member would be supplied with coverings for the feet and other exposed body parts and permitted to take a "secondary" personal wash. This might include a full body shower followed by redress.

Personnel then receive a medical checkup, including pulse, blood pressure, and temperature. Weight and EKG readings are optional. Treated according to their needs and given warm or cool fluid replenishment as environmental conditions dictate, they finally are allowed to rest.

There are various methods to decontaminate.

Decontamination Showers

These can be set up in a short time, require a minimum of personnel, and provide for rapid cooling, gross decontamination, and a first rapid rinse. On the down side, they have limited effectiveness, may force a contaminant into the suit, use a lot of water, and, consequently, create runoff containment and disposal problems.

Partner (Mutual) Decontamination

This method allows one member of the entry team to decontaminate the other, then the "favor" is returned. While it allows for decontamination to be performed in units with few personnel, it increases the demands on each member of the entry team.

Shower Trailers

Trailers provide yet another way to decontaminate. Though quick to set up once one is available, there are more than a few costs involved in building, maintaining, and storing them.

Disposable Suits

This method requires a great deal of thought and possibly money, depending upon the type(s) of suit(s) selected.

The Unprotected Person: A Victim

Decontamination of persons, including improperly protected emergency responders who have fallen victim to contamination, can require gross, secondary, or tertiary decontamination. Each of these has been discussed in the previous unit.

While not normally thought of as decontamination, the use of hyperbaric chambers to rid the body's system of gaseous hazards such as nitrogen and carbon monoxide could be considered tertiary decontamination.

Victim Assessment

General victim assessment protocol requires that information about the victim be compiled rapidly, thoroughly, and accurately. It also is critical that the information be transmitted to the receiving health-care facility as soon as possible. This should include knowledge of the victim's being ambulatory or not, known injuries, and known contaminants.

The hospital will want to know how the injury occurred. Chemical injuries always should be considered a likely possibility with contamination. They may not be visible, but chemical action causes damage to many susceptible organs and tissues within a body. The hospital also will want to know the nature of the injury and its severity.

Knowledge of the degree and type of contamination to which the victim was exposed will be paramount: whether it was internal or external exposure, the surface area affected, the number of contaminants, and the duration of exposure. Every bit of information is important.

Relationship of Decontamination and Treatment

It is imperative that a victim be given a thorough and accurate assessment, so as to prioritize physical and chemical injuries and to identify ongoing problems. Medical intervention may become necessary before decontamination. A victim may require defibrillation, installation of IVs, injections, or resuscitation.

However, the use of electronic diagnostic equipment such as EKGs or defibrillators has two main drawbacks. First, the equipment is not intrinsically safe, so it cannot be decontaminated easily; and second, the equipment may be damaged or destroyed by chemicals.

Starting intravenous solutions, administering injections, and rescue breathing generally should not be performed until the victim has been decontaminated, at least locally, that is, in the immediate area of an injection. Otherwise, there is a danger of internal introduction of contaminant.

Efforts to intervene medically must be preceded by some serious risk analysis. To be treated before decontamination, the victim should be experiencing an immediate life-threatening condition. It must be remembered that even extremely serious injuries may not produce an immediate life-threatening state. It may be safer to decontaminate the victim first.

In either case, the victim will have to be decontaminated before being transported to a hospital.

Decontamination and Transport

The victim may be ambulatory or nonambulatory. If ambulatory, the decontamination process is basically as explained above. The victim should be advised of the need for the procedure, what to expect, and what to do. Some measure of privacy should be afforded. Treatment, if necessary, normally would be provided after decontamination. The victim then is packaged and transported.

If a victim is nonambulatory, decontamination personnel must do everything for him or her. As a result, more people will be needed to handle not only team members but the nonambulatory victims. The medical personnel must be suit-qualified to assess and treat, if they will be working in the hot zone or on contaminated victims.

The process is labor-intensive and will require an additional corridor, more containments, and a great deal of coordination.

In preparing them for transport, the victim and litter must be packaged. All nonessential equipment shall be removed from the vehicle and all surfaces draped. Transporting personnel should wear appropriate personal protective equipment (PPE). They shall establish and maintain communications and be prepared to administer treatment, if necessary.

Equipment Decontamination

The types of equipment that might need decontamination include anything useful at a hazardous materials scene, such as PPE, SCBA, uniforms, tools, and even the apparatus.

Among the decontamination considerations three things come to the fore: cost, texture, and porosity. Is it disposable? Can we afford to throw the thing out? If the item has a very rough surface or is porous, and the contaminant is potent, decontamination may not be possible. The money saved in reusing a piece of contaminated equipment would be no consolation if a member fell ill from something like pesticide exposure a week later.

Permeation and impregnation of equipment fabric will leave residual contamination. Over time, it will result in exposure to personnel in one or more synergistic ways. At a minimum, the PPE can only become degraded, perhaps to a point where it no longer would provide the protection it is supposed to.

If decontamination efforts are called for and the suit is perceived as still usable, the suit should undergo gross and secondary decontamination processes, be removed using a sterile technique, overpacked, and tested.

If postdecontamination inspection shows damage, repair the garment or dispose of it appropriately. If the equipment shows evidence of a contaminant and all efforts to remove it have proved fruitless, contact the manufacturer. At times, only they or a contractor will be able to safely remove a particularly stubborn contaminant without degrading the suit. However, when in doubt, throw it out.

The key point to remember is this: if there is contamination, one must do everything possible not to spread it by contaminating others or one’s equipment. Careless handling of the contaminated victim can lead to contaminated responders and equipment. This is to be avoided.

One of the potentially unfortunate results of careless response when there is contamination is transporting contaminated victims who in turn contaminate the response vehicle and the facility itself. There is no need for this.

A well-thought-out and carefully executed response will prevent this from happening.

UNIT 7:
RESPIRATORY TOXICOLOGY

OBJECTIVES

The students will be able to:

1. *Given a list of alternatives and working individually, identify*
    a. *The correct definitions for three types of toxicologic harm that can affect the respiratory system.*
    b. *Two symptoms each for three levels of exposure to carbon monoxide.*
    c. *Four types of pathophysiology and four treatment procedures for pulmonary injury.*
    d. *Four presentation characteristics and four treatment procedures for methemoglobinemia.*
    e. *Three pathophysiological effects and four treatment procedures for reduced oxygen levels.*
    f. *Three pathophysiological effects and three treatment procedures for irritant gases.*
2. *Working in small groups and using a scenario, identify problems, safety concerns, patient care concerns, and appropriate levels of personal protective equipment (PPE) for the incident.*
3. *Working in small groups and using a scenario, analyze the medical data available and recommend suitable treatment.*

Activity 7.1

High School Incident

Purpose

To identify the real concerns, problems, and response associated with a simulated incident in a high school.

Directions

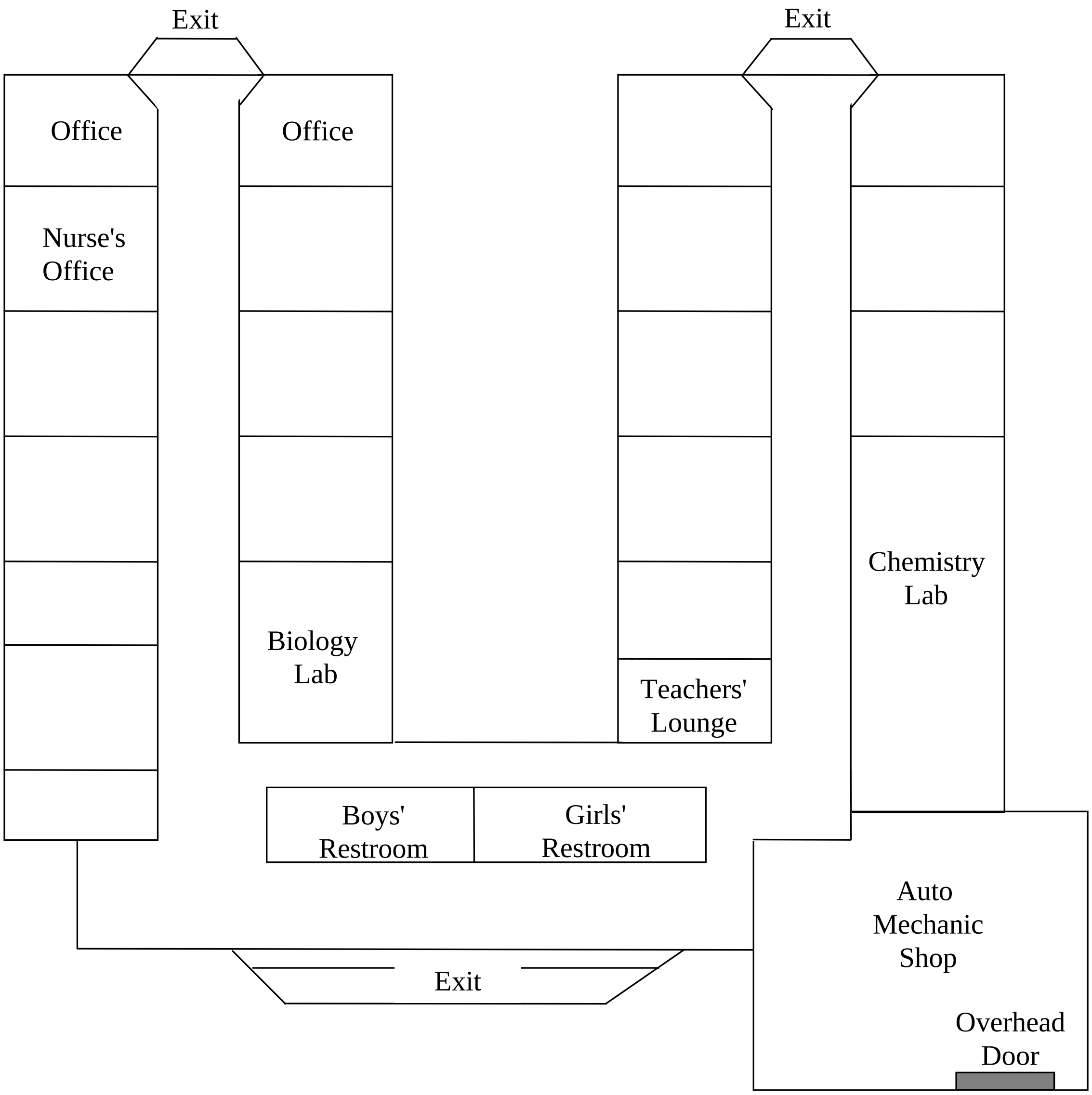
1. Work in small groups.

2. Using the scenario information provided in Handout 7-1 and referring to the floor plan of the high school on the next page, answer the questions on the Worksheet.

3. You will have no more than 10 minutes.

Activity 7.1 (cont'd)

Floor Plan



Activity 7.1 (cont'd)

Worksheet

What problems do you see?

What safety concerns do you have for the emergency medical responders?

What are your patient care concerns?

What are the symptoms?

How long have the victims been displaying the symptoms?

Where were the victims prior to arriving at the nurse's station?

How long had they been at the previous location?

Was anything unusual there?

To what does it appear they have been exposed?

What would seem to be an acceptable treatment?

What is the appropriate level of hazardous materials response?

BASIC CONCEPTS

Respiratory Toxicology

The lungs are the only internal organs that have vital functional components in constant contact with the external environment. The lungs have the largest exposed surface area of any organ. There are about 70 to 100 square meters of surface area within the respiratory system compared to about 2 square meters for the skin and 10 for the gastrointestinal tract.

As we saw earlier, the respiratory tract is divided into three regions: the nasopharyngeal, the tracheobronchial, and the pulmonary acinus. The pulmonary acinus contains the respiratory bronchioles (terminal bronchioles) and about 100 million alveoli.

When particles are inhaled into the lungs, they tend to settle according to their diameter. Particles of 5 to 30 microns usually settle in the nasopharyngeal region, where they are swept away as described earlier.

Particles of one to five microns will end up in the tracheobronchial tree and those of less than one micron may very well make it all the way to the alveoli.

Agents of Harm

Agents that harm the respiratory system or interfere with its function are generally classified according to the type of harm they cause. Asphyxiants can prevent oxygen from reaching the pulmonary tree, or the cells themselves. Irritants can cause hypersecretion and damage to respiratory structures. Necrotics may cause massive destruction. Fibrotics may result in fibrotic growth in lung tissue. Allergens may invoke anaphylactic reaction and carcinogens may cause cancer. Some materials that enter the lungs cause no harm to the respiratory tract, but use the lungs as a pathway into the bloodstream for the toxin to travel to its respective target organ.

Respiratory Injuries at Fire Scenes

Carbon monoxide (CO) is a product of most fires, especially when there is incomplete combustion or pyrolysis of combustible materials. Carbon monoxide levels are likely to be highest during the overhaul phase, which is the time a firefighter is least likely to be protected by self-contained breathing apparatus (SCBA). Some of the sources for carbon monoxide include wood, paper, synthetics, and household furnishings; in other words, just about anything that is organic and burns.

The Pathophysiology of Carbon Monoxide

The pathophysiology of carbon monoxide is based on the creation of carboxyhemoglobin. Instead of the hemoglobin in the red blood cell binding with and carrying oxygen, it preferentially binds with the carbon monoxide, creating carboxyhemoglobin. This causes a breakdown in the process of oxidative cellular metabolism. Without oxidative metabolism, there will not be enough ATP present in the cell for the cell to live. If the deprivation is of sufficient length, the cell will die. The type of presentation expected with carbon monoxide poisoning is based on the amount of hemoglobin that becomes saturated with CO.

In what is considered a mild exposure, there will be about 20 to 30 percent saturation and the manifestation will be headache, nausea, dizziness, and tachycardia. Moderate exposure is 30 to 50 percent and this amount is associated with synocope and dyspnea. Severe exposures, over 50 percent, may result in seizures, coma, and possibly death. There are also other symptoms and signs associated with carbon monoxide poisoning that may manifest at varying levels of CO saturation in the blood.

Treatment

When addressing patients with carbon monoxide poisoning, consider variables that may increase the severity and rapidity of onset of manifestation. Pregnant patients may be more susceptible to CO poisoning and can be expected to become sicker sooner. High levels of physical exertion also may speed the onset of symptomology.

In some instances CO effects may be delayed. There have been instances of uneventful convalescence from a severe exposure to carbon monoxide with manifestation of symptoms up to three weeks later. Also consider that in an atmosphere of as little as one percent carbon monoxide, a firefighter may become too impaired to leave the area safely.

The treatment of carbon monoxide exposures is focused on returning the blood's oxygen-carrying capabilities to normal as quickly as possible. As with any other medical emergency, ABCs are a top priority. One hundred percent oxygen will offer some degree of competitive inhibition to the CO that will remarkably shorten the half-life of the carbon monoxide. The ideal treatment is a hyperbaric chamber.

Other Fire Scene Concerns

There are other concerns associated with the fire scene, among which is direct pulmonary injury. This can be caused by the inhalation of flame, super-heated fire gases, or steam, or by the corrosive effects of some inhaled fire gases.

The pathophysiology of these events generally will be noncardiogenic pulmonary edema, as the lungs try to defend themselves by hypersecretion, ciliary paralysis, bronchospasm, tissue sloughing, acid formation from certain convalent acid gases, and the loss of pulmonary surfactant.

Carbon monoxide poisoning and pulmonary injury may be the most common respiratory-related problems encountered, but there are other potentially toxic agents present in smoke as well.

Pulseoxymeters measure the saturation of the red blood cells and should read in the high 90 percent range on a normal patient. If the victim has been exposed to carbon monoxide, the pulseoxymeter still may read in the normal range. However, the victim is anoxic because part of that saturation is coattached to the blood cell. The pulseoxymeter cannot tell the difference.

There are other toxic products that can cause a false pulseoxymeter reading.

Asphyxiation Injury

Many injuries that result from scene activities at fire and hazardous materials incidents are the result of simple asphyxiation. This may result when a fire has consumed the available oxygen, there has been a slow oxidation process within a confined space, or the oxygen is displaced by other gases, even if these other gases are considered "inert." These gases may end up "inerting" the atmosphere, which means that oxidation cannot take place.

Pathophysiology

The pathophysiology of asphyxiation is quite straightforward: tissue hypoxia, anaerobic metabolism, and metabolic acidosis. The presentation of axphyxiation will consist of the following effects on the different systems:

- **The central nervous system.**

  Headache, confusion, loss of consciousness, restlessness, irritability, and combative behavior.

- **The respiratory system.**

  Hyperventilation, respiratory depression, and noncardiogenic pulmonary edema.

- **The cardiovascular system.**

  Sympathetic response and cardiovascular collapse.

- **Metabolic.**

  Respiratory acidosis and metabolic acidosis.

Treatment

Treatment of asphyxiation injury tends to be symptomatic. Oxygenation, ventilatory support, airway management, and advanced life support according to the signs observed, i.e., seizure control ACLS, may be needed.

Irritant Gases

Irritant gases are among the most common of hazardous materials. They include chlorine, ammonia, sulfur dioxide, phosgene, and the oxides of nitrogen.

The pathophysiology is based somewhat on the water solubility of the gas involved in the toxic event. The more highly soluble gases are chlorine, ammonia, and sulfur dioxide, which cause severe respiratory irritation as a result of the formation of corrosive solutions within the lungs. They may result in noncardiogenic pulmonary edema, will cause severe skin and eye irritation, but may in some instances tend to be self-limiting.

This self-limiting property is based on the fact that since the fumes of these materials are so irritating and uncomfortable, most persons will make a diligent attempt to escape their source. Of course, this is of little benefit if the person is trapped or in a confined space where escape is difficult or impossible.

The less soluble gases, such as phosgene and the oxides of nitrogen, tend to be less irritating. This allows not only for less motivation to escape, but also for a deeper penetration into the respiratory tree. This generally results in more severe lower airway damage which may be significantly delayed. There also would be less skin irritation and upper airway involvement. The irritant gases will present a variety of signs and symptoms that may in some cases be similar to those seen in pulmonary injury at fire scenes.

UNIT 8:
INGESTION INJURIES

OBJECTIVES

The students will be able to:

1. *Given a list of alternatives and working individually, identify*
    a. *Four general principles of ingestion injuries.*
    b. *Two concerns each of four treatment procedures for ingestion injuries.*
2. *Working in small groups and using a scenario, analyze the medical data available and recommend suitable treatment.*

Activity 8.1

High School Incident

Purpose

To identify the ingestion symptoms, analyze the circumstances surrounding their origin, and suggest acceptable methods of treatment for the high school incident.

Directions

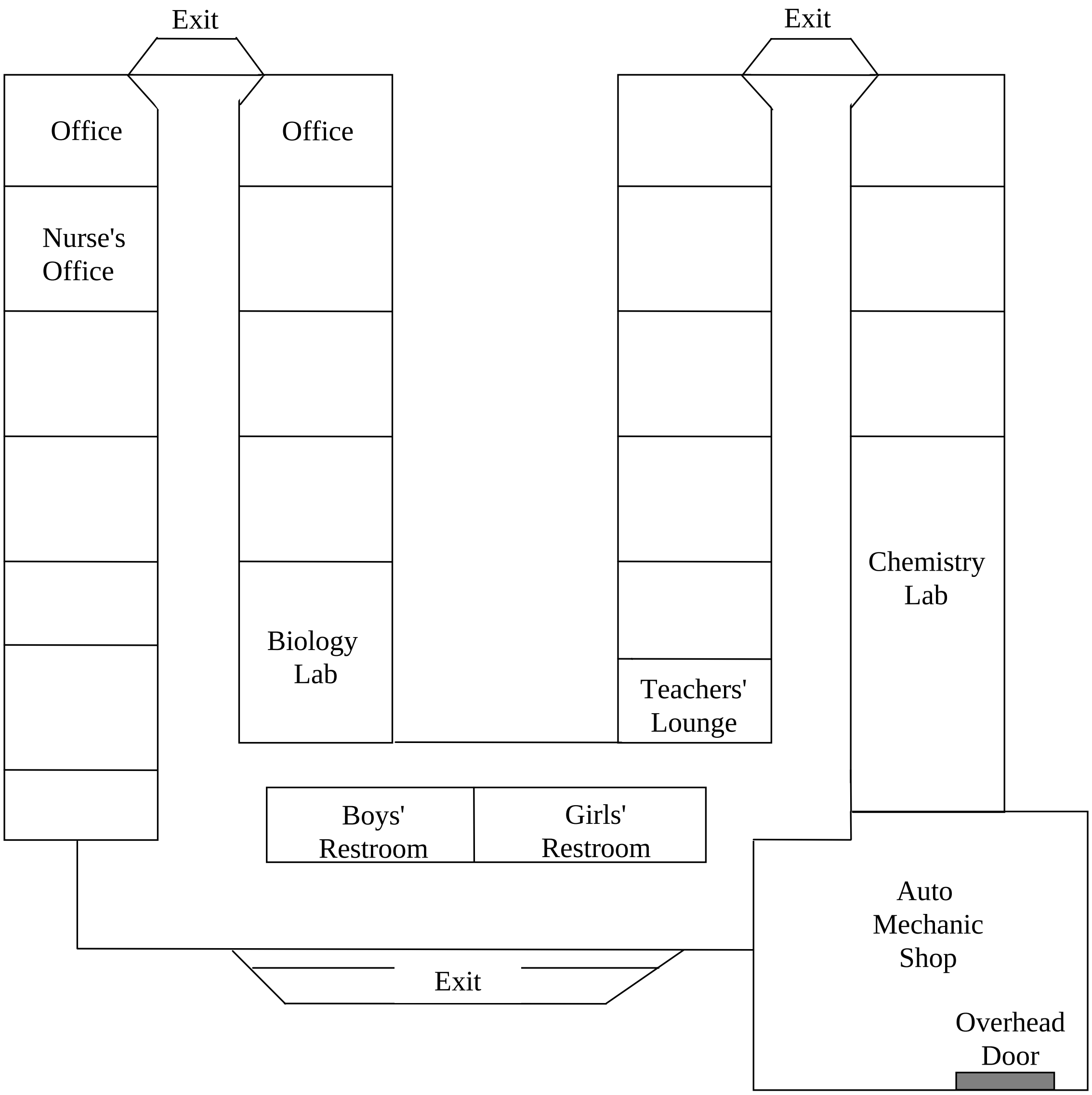
1. Work in small groups.

2. Using the scenario information provided in Handout 8-1 and referring to the floor plan of the high school on the next page, answer the questions on the following Worksheet.

3. You will have no more than 10 minutes.

Activity 8.1 (cont'd)

Floor Plan



Activity 8.1 (cont'd)

Worksheet

What are the symptoms?

What actions preceded the employees’ manifestation of these symptoms?

What can you infer from this?

What actions would you take?

INGESTION INJURIES

General Principles

Ingestion injuries at hazardous materials incidents should not be a major problem since there should be no hand-to-mouth contact by responders until such time as proper decontamination has occurred. The same cannot be said about protecting the airway and skin because respiration is a continuous event. It is therefore impossible to retract the skin away from the environment in the event of the unpredictable. Unfortunately, there will always be the possibility of inhalation or skin contact with a chemical because of human error, equipment failure, or unforeseen catastrophic failure of containers. In other words, the gastrointestinal tract should, in theory, be the easiest route to protect against the entry of toxic products.

The prognosis of a patient who has ingested hazardous materials is dependent on aggressive removal of the toxin from the body. Because protocols vary widely from jurisdiction to jurisdiction, medical control must be the determining methodology for treatment of ingestion injuries, as well as all other hazardous materials injuries.

Treatment

Treatment should be geared toward rapid removal or neutralization of the ingested agent, or in some instances, dilution of the ingested agent.

One method of removal is through the induction of emesis, but this may be contraindicated in some instances. These contraindications extend to any patient who is, or may very soon be, comatose; who has ingested caustics; or who has ingested petroleum products, although there may be exceptions in this case. For instance, if the petroleum product ingested was used as a carrier for a pesticide, emesis may be indicated.

Gastric lavage is another option for removing poisons from the gastrointestinal tract, but it too may be contraindicated in the case of caustic ingestion. With petroleum products, an endotracheal tube should be in place. In the case of ingested acids, gastric lavage may be indicated, but once again, medical control must dictate the proper actions. Gastric lavage is a questionable field therapy, but the longer lavage is delayed, the less effective it will be.

An old mainstay in the induction of emesis is syrup of ipecac. It seems to be falling out of favor with many, but there are some systems that still advocate its use. It has its own inherent hazards such as the possibility of aspiration, and the rare occasions where seizures may be induced. Many argue the efficacy of this treatment.

Activated charcoal can be used to bind to a poison so it can then be eliminated or lavage can occur. It is not effective for all toxins and is sometimes used along with ipecac after emesis has occurred.

Using cathartics is another method of toxin removal from the gastrointestinal tract. It is based on the theory that if the toxin is moved through the tract more rapidly, less toxin will be absorbed and metabolized by the body. It can be very messy and is not a common field therapy. Sometimes cathartics also are ineffective in deeply comatose patients. They are contraindicated in caustic ingestions, and magnesium sulfate and sorbitol are the most common remedies used.

Neutralizing agents are not commonly used in the field either. They are generally specific to the poison ingested. For instance, for mercury ingestion, sodium formaldehyde sulfoxylate is used. For iron poisoning, sodium bicarb; for iodine, starch; and for strychnine, potassium permanganate.

Ingestion injuries can be tricky. These recommendations are to be followed carefully and prudently.

When all is said and done, the best advice is to follow local protocols, exercise medical control and call the closest Poison Control Center as soon as possible.

Three Rules of Thumb

1. Follow local protocols.
2. Exercise medical control.
3. Call the Poison Control Center.

UNIT 9:
DERMAL TOXICOLOGY

OBJECTIVES

The students will be able to:

1. *Given a list of alternatives and working individually, identify*
    a. *Three characteristics of the epidermis.*
    b. *Four factors that can enhance absorption of toxins through the skin.*
    c. *The most common treatments for dermal contamination.*
2. *Working in small groups and using a scenario, identify problems, safety concerns, patient care concerns, and appropriate levels of personal protective equipment (PPE) for the incident.*

Activity 9.1

High School Incident

Purpose

To identify the dermal effects and suggest acceptable methods of treatment at the high school incident.

Directions

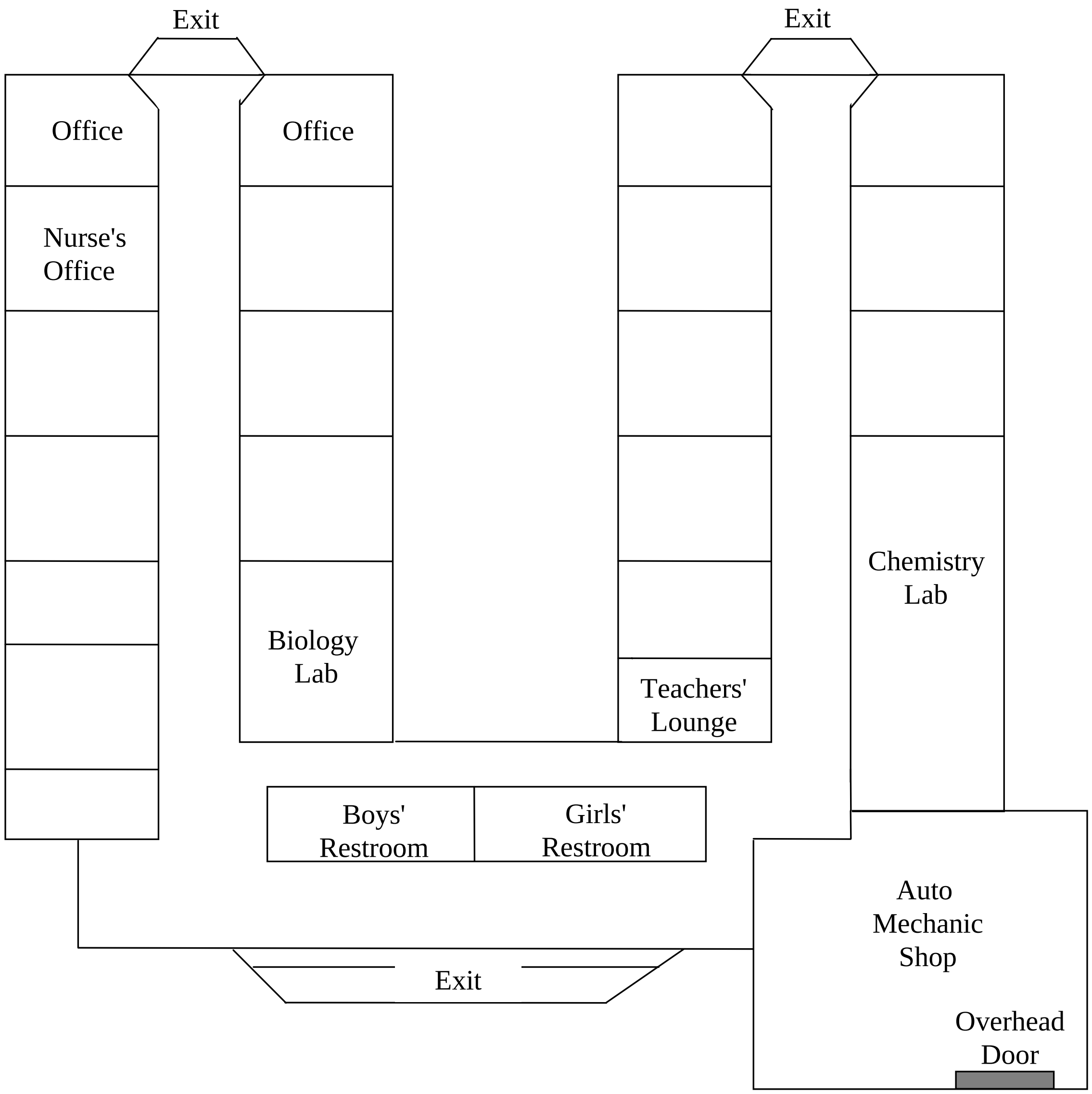
1. Work in small groups.

2. Using the scenario information provided in Handout 9-1 and referring to the floor plan of the high school on the next page, answer the questions on the following Worksheet.

3. You will have no more than 10 minutes.

Activity 9.1 (cont'd)

Floor Plan



Activity 9.1 (cont'd)

Questions

What problems do you see?

What safety concerns do you have for the emergency medical responders?

What are your patient care concerns?

What is the appropriate level of hazardous materials response?

ANATOMY AND FUNCTION OF THE SKIN

The skin is the largest organ of the body by weight, and is therefore a highly susceptible target for entry of hazardous materials. The skin actually serves as a barrier to the outside environment. It is composed of two layers, the dermis and the epidermis. The epidermis is the outermost layer of the skin, is very thin, and is composed of cells that are dead or dying. The epidermis is replaced about every two weeks as the old cells dehydrate and fall or are scraped away. The dermis lies just beneath the epidermis and contains sweat glands and ducts, sebaceous glands, connective tissue, fat, hair follicles, and blood vessels. The follicles and the sweat glands penetrate the epidermis. The epidermis plays an important role in the permeability of the skin.

Intact skin performs many critical functions, among them the ability to resist the entry of some chemicals. The skin also serves as a barrier to bacteria. The sebaceous glands secrete fatty acids that tend to be bacteriostatic and fungistatic and assist this function. The melanocytes serve to pigment the skin and help protect from sunlight. The sweat glands are critical to the regulation of body heat. The connective tissue found in the dermis provides elasticity for protection against mechanical energy. The lymph system, which also runs through parts of the dermis, is important to the body's immune response. The absorption of foreign substances through the skin is dependent on the health of the skin and the properties of the substance involved.

Factors Influencing Skin Absorption

- Breaks in the skin
- Increases in hydration, skin temperature, peripheral blood flow, concentration of the substance, contact time, contact area
- Altered skin pH (5)
- Decreased particle size
- Presence of surface-active substances
- Induced ionic movement by ionic change
- Solubility of substance

Contact with some hazardous materials can cause local damage, or the toxin may pass through the skin to create systemic problems. Irritation of the skin can be caused by direct chemical injury, allergic response, or by sensitivity to light. Eyes can be affected in much the same way as the skin, except that the eyes are much more sensitive and more susceptible to destruction. Some chemicals also may enter the eyes without damage but have systemic effects. Some chemicals can enter the body somewhere else and cause systemic damage to the eyes.

The proper use of PPE and following some common-sense practices such as keeping a safe distance upwind from the hazard can go a long way toward protecting the skin from harm.

One should never expose oneself or one's colleagues needlessly to save others. Responders need to take the proper precautions before exposing themselves and risking harm to the skin or to any other organ.

UNIT 10:
SYSTEMIC TOXICOLOGY

OBJECTIVES

The students will be able to:

1. *Given a list of alternatives and working individually, identify*
    - a. *Three characteristics of direct chemical action on the nervous system.*
    - b. *Three substances associated with liver damage.*
    - c. *Three chemicals that are toxic to kidneys.*
    - d. *Three mechanisms that can cause blood damage.*
    - e. *Four agents that can suppress bone marrow.*
    - f. *Three agents that can damage platelets.*
    - g. *Two differences between teratogens and mutagens.*
    - h. *Five suspected agents that can cause reproductive damage.*
2. *Working in small groups and using the same scenario, indicate the implications of the growing problem, list additional safety and patient care concerns, and identify suitable protective equipment for the medical responder.*

Activity 10.1

High School Incident

Purpose

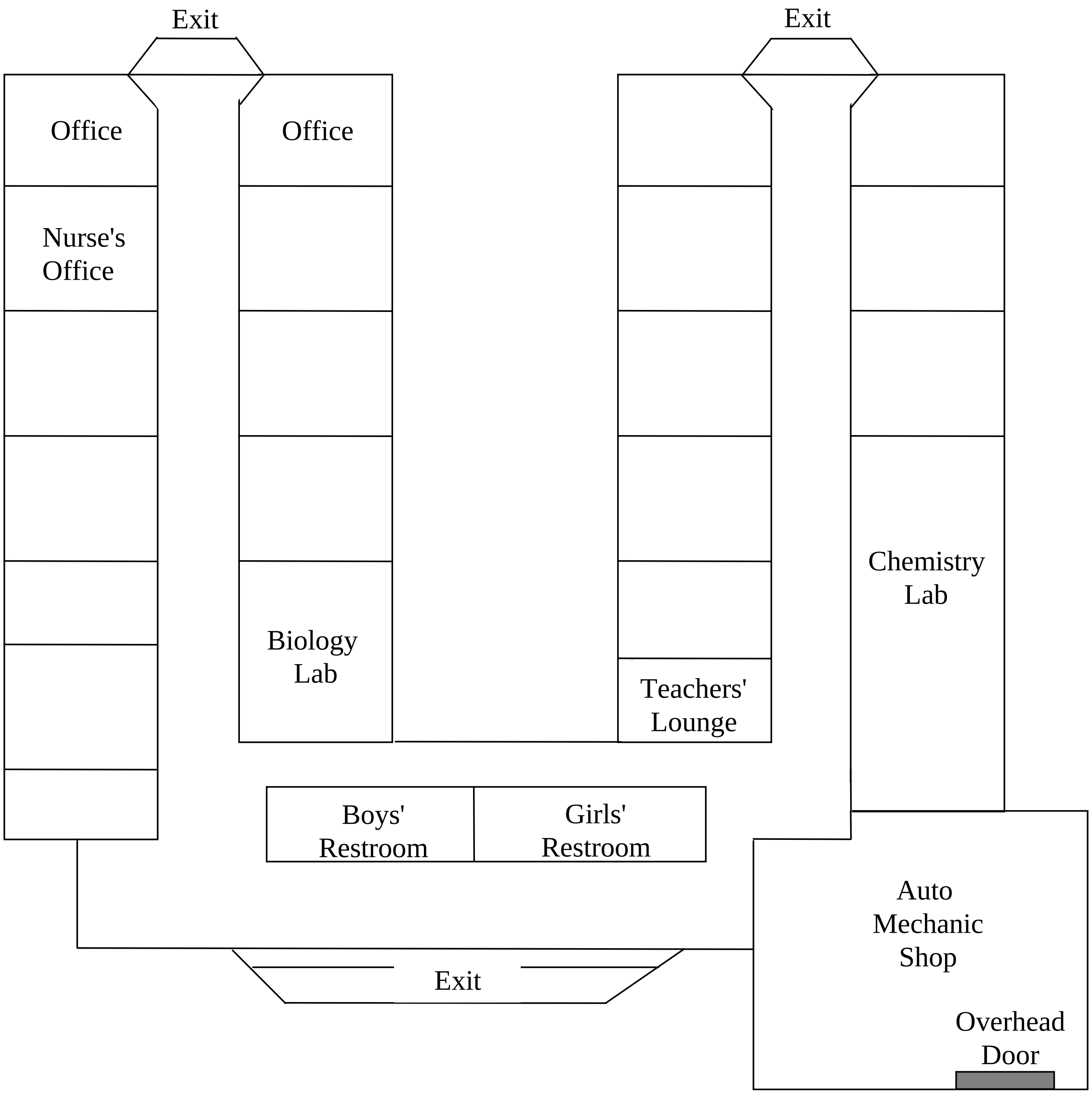
To continue the multistep analysis process that has occurred in the previous activities using an escalated situation at the high school.

Directions

1. Work in small groups.
2. Using the scenario information provided in Handout 10-1 and referring to the floor plan of the high school on the next page, answer the questions on the Worksheet.
3. You will have no more than 15 minutes.

Activity 10.1 (cont'd)

Floor Plan



Activity 10.1 (cont'd)

Worksheet

How has the problem grown?

What are some implications of this development?

What additional safety concerns do you now have for the emergency medical responders?

What are your patient care concerns now?

What is the appropriate level of hazardous materials response?

Activity 10.2

Incident at the Community Pool

Purpose

To allow you to individually apply the major principles presented in this course using a scenario.

Directions

Part I

After examining the diagram of the pool area, answer the following questions. You will have about 10 minutes to do so.

1. What is your normal response to this alarm?

2. How many responders will come to this call?

3. What are your concerns for responder safety?

Part II

After examining the diagram of the pool area, if still necessary, answer the following questions. You will have about 15 minutes to do so.

1. What is your most likely diagnosis?

2. Will you call for any extra units? If so, how many? Remember you still have the rest of your community to cover.

3. What is your strategy for this incident?

4. Identify the problem that confronts you.

5. Are there any risk factors to the responders or patients?

Part III

Answer the following questions. You will have about 20 minutes to do so.

1. What is your next action?

2. Are you going to call for additional units?

3. Are the two groups of patients suffering from the same problem?

4. How would you modify your strategy to handle this incident?

5. Do you have any concerns for responder or patient safety?

6. What are the risks posed by this incident?

7. Now what is the problem that confronts you?

Part IV

Answer the following questions. You will have about 20 minutes to do so.

1. How would you modify your strategy?

2. What additional resources would you call in?

3. Now what is the problem that confronts you?

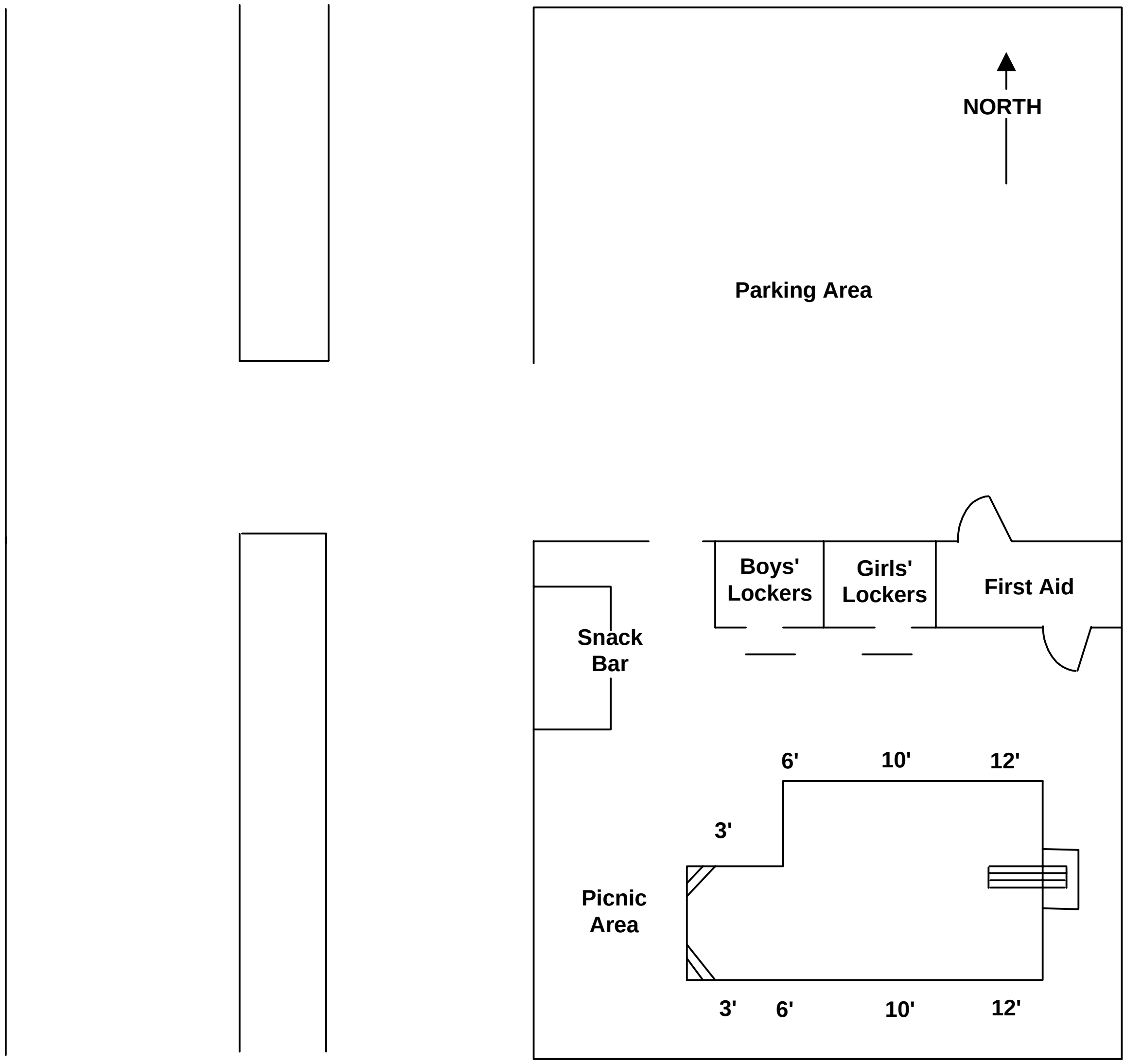
4. As an awareness-trained responder what are some of your actions going to be?

5. What are you going to do about the missing worker?

6. What are your concerns about responder and patient safety?

7. How would you protect other responders and the patients?

8. What other information do you need and where can you get it?


NORTH
Parking Area
Boys' Lockers
Girls' Lockers
First Aid
Snack Bar
6'
10'
12'
3'
Picnic Area
3'
6'
10'
12'

NERVOUS SYSTEM DAMAGE

Many chemicals will enter the body at one point and then travel to a different area of the body to cause injury. The nervous system is vulnerable to injury by direct chemical action to and through hypoxia. The nervous system tends to have a high metabolic rate and has a low capacity for anaerobic metabolism. Cell death will occur within minutes of complete anoxia and some cells will die with only a partial oxygen deficiency. The cell can be affected by both simple and chemical asphyxiants. The nervous system also can be affected by direct chemical action, and the symptoms that will be seen run the gamut. Generally, there will be paralysis of nerve function, and respiratory arrest may ensue.

LIVER DAMAGE

The liver is a vital organ in the human organism, because of its function of biotransformation of nutrients which cannot be used in their ingested forms. They must be "broken down" by the liver into usable nutrients. Liver damage may be acute, as when there is active death of individual liver cells on a large scale. Liver damage also may be chronic, as in the case of cancer or cirrhosis. The metabolic function of the liver can be affected by diet, hormonal activity, and alcohol consumption and the use of other drugs. Quite often, the liver will try to biotransform the toxins taken into the body, but the resulting metabolites may themselves be toxic. There are many substances associated with liver damage, including

- hydrocarbons;
- hydrocarbon derivatives;
- arsenic; and
- heavy metals.

KIDNEY DAMAGE

The kidneys constitute only about 1 percent of the total weight of the body, but receive about 20 to 25 percent of the total blood flow of the body at rest. The kidneys have very high requirements for oxygen and nutrients, and many chemicals are toxic to the kidneys, including

- heavy metals;
- halogenated hydrocarbons;
- carbon disulfide; and
- many pesticides.

As in the case of the liver, there are many others.

HEMOTOXINS

Many mechanisms can cause harm to the bloodstream. There can be diminished blood cell production, destruction of blood components, and disruption of the oxygen-carrying capability of the blood. Most blood components are manufactured in the bone marrow, including red blood cells, white blood cells, and platelets. The platelets are instrumental in the clotting of blood, and the red blood cells, of course, transport oxygen. The white blood cells are principally involved in immune response and protection against foreign invaders.

Bone marrow production may be suppressed by one of the following substances or processes:

- arsenic;
- bromine;
- halogenated hydrocarbons;
- ionizing radiation;
- benzene; and
- many pesticides;

The following may damage platelets:

- aspirin;
- benzene;
- rat poison (warfarins); and
- halogenated hydrocarbons.

The red blood cells are particularly vulnerable to the following substances:

- mercaptans;
- nitrites;
- aniline;
- aromatics;
- carbon monoxide; and
- TNT.

White blood cells are susceptible to damage by

- benzene; and
- phosphorus compounds.

REPRODUCTIVE SYSTEM DAMAGE

The reproductive system is another common target for toxic chemicals and even some compounds not generally thought of as toxic. The potential problems associated with the reproductive system include sterility, infertility, abnormal sperm count, low sperm count, and hormonal imbalances. Other problems include the devastating effects of teratogens and mutagens.

Teratogens

Teratogens are those compounds that can cause an unborn child to be born with deformities as a result of the expectant mother being exposed to or injured by chemicals or other compounds. An example would be the birth of a child to a mother who used cocaine, alcohol, or other substances during the pregnancy; the result can be a baby born with birth defects or deformities. In fact, the word teratogen comes from a Latin term referring to monsters. Agents known to cause teratogenic effects in humans include the following:

- anesthetic gases;
- organic mercury compounds;
- ionizing radiation;
- thalidomide; and
- German measles.

Mutagens

Mutagens are compounds that cause changes (mutations) in the genetic code, altering DNA. This may be caused by chromosomal breaks, rearrangement of chromosome pieces, gain or loss of an entire chromosome, or changes within the gene. Mutagens may result in birth defects, even in a later generation. A popular example of a mutagen is LSD. It was claimed to cause mutations in babies conceived many years after its use. Although this was widely presented in the media as fact, in truth there was never any real substantiation that LSD was a true mutagen. Many studies found no connection between birth defects and the use of LSD.

On the other hand, aspirin, caffeine, fever in expectant mothers, and X-rays all have been shown to cause damage to white blood cell chromosomes.

Agents that have been shown to be true mutagens include the following:

- ethylene oxide;
- ethyleneimine;
- ionizing radiation;
- hydrogen peroxide;
- benzene; and
- hydrazine.

CARCINOGENS

There also is evidence that carcinogens may be connected to reproductive damage. Many carcinogens can be metabolized so that they react with DNA, and many also are mutagens. Defects in DNA predispose individuals to the development of cancer. It has been shown that cancer is inheritable at the cellular level. Most, if not all, cancers display chromosomal abnormalities.

Other compounds suspected of reproductive damage are:

- heavy metals;
- DDT;
- chlordane;
- PCBs;
- dioxin;
- vinyl chloride; and
- many pesticides.

APPENDIX A

SAMPLE MSDS

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PPG INDUSTRIES, INC.

CHLORINE
PAGE: 1

MSDS NUMBER:	0119		
DATE:	04/26/94		
EDITION:	014		
TRADE NAME:	CHLORINE		
CHEMICAL NAME/SYNONYMS:	CHLORINE		
CHEMICAL FAMILY:	HALOGEN		
FORMULA	CL2	CAS NUMBER:	007782: 50 5
U.S. DOT SHIPPING NAME:	CHLORINE	2.3 9	
U.S. DOT HAZARD CLASS:	(POISON GAS-INHALATION HAZARD-HAZARD ZONE B)		
SUBSIDIARY RISK:	N/A		
I.D. NUMBER:	UN1017		
PACKING GROUP:	N/A		
REPORTABLE QUANTITY:	10 LBS/4.54 KG		

CHLORINE IS A MARINE POLLUTANT.
TDG CANADA: CLASS 2.3 (5.1) PER SU4175

SECTION 1-PHYSICAL DATA

BOILING POINT @ 760 MM HG:	-29.31 F (-34 C)
VAPOR DENSITY (AIR=1):	2.67 @ 70 F
SPECIFIC GRAVITY (H20=1):	1.468 LIQUID @ 0/4 C
PH OF SOLUTIONS:	ACIDIC
FREEZING/MELTING POINT:	-101 C
SOLUBILITY (WEIGHT % IN WATER):	0.73 @ 20 C
BULK-DENSITY:	3.2 GRAMS/LITER
VOLUME % VOLATILE:	100
VAPOR PRESSURE:	4996 MM HG @ 68 F
EVAPORATION RATE:	N/A
HEAT OF SOLUTION:	UNKNOWN

APPEARANCE AND ODOR:

GREENISH-YELLOW GAS UNDER ATMOSPHERE CONDITIONS OR AMBER LIQUID UNDER PRESSURE. PUNGENT AND IRRITATING ODOR.

SECTION 2 - INGREDIENTS

MATERIAL	PERCENT
CHLORINE	99.9
INERT INGREDIENTS	BALANCE

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CHLORINE
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SECTION 3 - FIRE/EXPLOSION HAZARD DATA

FLASH POINT (METHOD USED): NON-FLAMMABLE
FLAMMABLE LIMITS IN AIR % BY VOLUME)
LEL: N/A
UEL: N/A
EXTINGUISHING MEDIA: N/A

SPECIAL FIRE FIGHTING PROCEDURES:
FIREFIGHTERS MUST WEAR NIOSH/MSHA-APPROVED, SELF-CONTAINED BREATHING APPARATUS WITH FULL FACE-PIECE. CHLORINE CONTAINERS SHOULD BE IMMEDIATELY REMOVE FROM THE VINCINITY OF A FIRE. IF THEY CANNOT BE REMOVED, NOTIFY FIREFIGHTERS AND SPRAY WATER TO COOL CONTAINERS. DO NOT SPRAY WATER ON LEAKING CONTAINER
UNUSUAL FIRE AND EXPLOSION HAZARDS:
WILL SUPPORT COMBUSTION. REACTS READILY WITH HYDROCARBONS, ALCOHOLS, ETHER AND SOME METALS, POSSIBLY WITH EXPLOSIVE VIOLENCE. WILL REACT WITH (BURN) STEEL CONTAINERS AT TEMPERATURES ABOVE 450 F.

SECTION 4 - HEALTH HAZARD DATA

LC50 INHALATION:	(RATS) 293 PPM, 1-HOUR
LD50 DERMAL:	SEE SECTION 5
SKIN/EYE IRRITATION	SEE SECTION 5
LD50 INGESTION:	SEE SECTION 5

FISH, LC50 (LETHAL CONCENTRATION) (BLUEGILL) 0.4 MG/L, 96-HOUR

CLASSIFICATION:

INHALATION:	SEE SECTION 5
SKIN:	SEE SECTION 5
SKIN/EYE:	SEE SECTION 5
INGESTION:	SEE SECTION 5
AQUATIC	SEE SECTION 5

SECTION 5 - EFFECTS OF OVEREXPOSURE

IS CHEMICAL LISTED AS A CARCINOGEN OR POTENTIAL CARCINOGEN?
NTP - NO IARC - NO OSHA - NO

MEDICAL CONDITIONS GENERALLY AGGRAVATED BY EXPOSURE:
NONE KNOWN.

PERMISSIBLE EXPOSURE LIMITS:
OSHA: 0.5 PPM, 8-HOUR TWA, (TIME-WEIGHTED AVERAGE); 1 PPM, 15-MINUTE STEL (SHORT-TERM EXPOSURE LIMIT); 29 CFR 1910.1000, REV 3/1/89.

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ACUTE:

INGESTION: NOT APPLICABLE FOR GAS. LIQUID COULD PRODUCE SEVERE BURNS AND INJURY ON CONTACT.

EYE/SKIN: LIQUID AND CONCENTRATED GAS COULD PRODUCE SEVERE BURNS AND INJURY ON CONTACT.

CHLORINE GAS CAN CAUSE A STINGING OR BURNING SENSATION TO THE EYES AT CONCENTRATIONS AS LOW AS 3-6 PPM.

SKIN EXPOSURE TO GAS MAY CAUSE A BURNING SENSATION, INFLAMMATION, OR EVEN BLISTER FORMATION. WORKERS IN ELECTROLYTIC CHLORINE PLANTS MAY DEVELOP A FORM OF ACNE, PARTICULARLY EVIDENT AROUND THE EARS.

INHALATION: LETHAL CONCENTRATION FOR RABBITS, CATS, AND GUINEA PIGS BASED ON 30-60 MINUTE EXPOSURE = 0.4-0.9 MG/L AIR (280-630 PPM). INHALATION CAN CAUSE COUGHING, SNEEZING, SHORTNESS OF BREATH, SENSATION OF TIGHTNESS IN THE CHEST, AS WELL AS SEVERE RESTLESSNESS OR ANXIETY, NAUSEA, AND VOMITING. THE NOSE AND THROAT MAY BECOME IRRITATED; A STINGING AND BURNING SENSATION MAY BE EXPERIENCED. IMMEDIATE FATALITIES CAN OCCUR AS A RESULT OF SUFFOCATION. DELAYED FATALITIES CAN OCCUR AS A RESULT OF PULMONARY EDEMA (FLUID IN THE LUNGS). FOR THIS REASON, REST AND IMMEDIATE ATTENTION AFTER INHALATION IS IMPORTANT. PERSONS WITH KNOWN CARDIOVASCULAR OR LUNG PROBLEMS SHOULD NOT RISK CHLORINE EXPOSURE.

STUDIES HAVE BEEN CONDUCTED EXPOSING HUMAN VOLUNTEERS TO AIRBORNE CONCENTRATIONS OF CHLORINE BETWEEN 0.5 AND 2 PPM FOR UP TO 8 HOURS. IN THESE STUDIES, EIGHT-HOUR EXPOSURES TO 1 PPM PRODUCED TRANSIENT CHANGES IN PULLMONARY FUNCTION AND INCREASED SUBJECTIVE IRRITATION. EIGHT-HOUR EXPOSURES AT 0.5 PPM PRODUCED NO SIGNIFICANT CHANGE IN PULMONARY FUNCTION AND LESS SEVERE SUBJECTIVE IRRITATION.

CHRONIC: REPEATED EXPOSURES CAN RESULT IN A LOSS OF ABILITY TO DETECT THE ODOR OF CHLORINE. LONG-TERM EXPOSURES MAY CAUSE DAMAGE TO TEETH AND INFLAMMATION OR ULCERATION OF THE NASAL PASSAGES.

A STUDY WAS CONDUCTED ON DIAPHRAGM CELL WORKERS AT 25 PLANTS MANUFACTURING CHLORINE IN NORTH AMERICA WHERE EXPOSURES RANGED FROM 0.006 PPM TO 1.42 PPM WITH A MEAN OF 0.146 PPM. THE STUDY FOUND THAT THESE CHLORINE WORKERS WERE NOT AFFECTED IN ANY MEASURABLE WAY BY YEARS OF EXPOSURE TO LOW LEVELS OF CHLORINE. THERE WAS NO HIGHER INCIDENCE OF ABNORMAL EKG'S OR PULMONARY FUNCTION AMONG THESE WORKERS.

ENVIRONMENTAL HAZARD: THIS PRODUCT IS VERY TOXIC TO FISH--KEEP OUT OF LAKES, STREAMS, OR PONDS.

FISH, LC50 (LETHAL CONCENTRATION):

FRESHWATER FISH

A. COLD WATER FISH (TROUT) - LC50 = 6-60 MICROGRAM/L OR 0.006-0.060 MG/L OR TOTAL RESIDUE CHLORINE AT DIFFERENT LIFE STAGES AND FOR

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DIFFERENT SPECIES.

B. WARM WATER FISH - LC50 = 0.09 - 0.3 MG/L OF TOTAL RESIDUE CHLORINE

EMERGENCY AND FIRST AID PROCEDURES

INHALATION:

IMMEDIATELY REMOVE PATIENT UPWIND FROM CONTAMINATED AREA. IF PATIENT IS BREATHING, PLACE IN A COMFORTABLE POSITION; KEEP WARM AND AT REST UNTIL A PHYSICIAN ARRIVES. IF BREATHING IS DIFFICULT, GIVE OXYGEN. IF BREATHING HAS STOPPED, GIVE ARTIFICIAL RESPIRATION, PREFERABLY MOUTH-TO-MOUTH. IN ALL ABOVE CIRCUMSTANCES, CALL A PHYSICIAN AS SOON AS POSSIBLE. REST IS RECOMMENDED AFTER CHLORINE EXPOSURE.

EYE OR SKIN CONTACT;

IMMEDIATELY FLUSH EYES WITH WATER (SOAP AND WATER FOR SKIN) FOR AT LEAST 15 MINUTES, WHILE REMOVING CONTAMINATED CLOTHING. IF IRRITATION OCCURS, CONSULT A PHYSICIAN. NEVER ATTEMPT CHEMICAL NEUTRALIZATION! DO NOT GIVE ANY MEDICATION EXCEPT UNDER SPECIFIC INSTRUCTIONS FROM A PHYSICIAN.

INGESTION:

THROAT IRRITATION: DRINKING MILK MAY HELP RELIEVE THE DISCOMFORT OF THROAT IRRITATION FROM CHLORINE EXPOSURE.

COUGHING: HOT COFFEE OR TEA IS OFTEN USED TO ALLEVIATE COUGHING INDUCED BY CHLORINE EXPOSURE.

NOTES TO PHYSICIAN (INCLUDING ANTIDOTES):

TREAT PATIENTS OF CHLORINE OVEREXPOSURE SYMPTOMATICALLY. ALSO, OBSERVE AND TREAT FOR POSSIBLE ONSET OF PULMONARY EDEMA, WHICH MAY BE DELAYED.

SECTION 6 -REACTIVITY DATA

STABILITY: STABLE
CONDITIONS TO AVOID: EXCESSIVE HEAT & CONTAMINATION OR CONTACT WITH MATERIALS
HAZARDOUS POLYMERIZATION: WILL NOT OCCUR
CONDITIONS TO AVOID: NONE
IMCOMPATIBILITY (MATERIALS TO AVOID):
ORGANIC MATERIALS SUCH AS HYDROCARBONS, ALCOHOLS, AND ETHER; AMMONIA, HYDROGEN, AMINES
HAZARDOUS DECOMPOSITION PRODUCTS:
NONE

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SECTION 7 - SPILL OR LEAK PROCEDURES

STEPS TO BE TAKEN IF MATERIAL IS SPILLED OR RELEASED:

IMMEDIATELY EVACUATE ALL PERSONNEL BY FIRST MOVING AT RIGHT ANGLES TO THE WIND DIRECTION UNTIL CLEAR OF THE EXPOSURE AREA. ONLY TRAINED PERSONNEL WEARING NIOSH/MSHA APPROVED, SELF-CONTAINED BREATHING APPARATUS OR FULL FACEPIECE AIRLINE RESPIRATORS WITH AUXILIARY SCBA'S OPERATED IN THE PRESSURE DEMAND MODE SHOULD BE PERMITTED TO ENTER AREA. NEVER PUT WATER ON A CHLORINE LEAK. TO LOCATE LEAK USE COMMERCIAL AMMONIA WATER (26 BE') IN A SQUEEZE BOTTLE OR A CLOTH TIED TO A STICK AND DIPPED IN AMMONIA WATER. WHEN AMMONIA WATER IS HELD NEAR (BUT NOT ON) A CHLORINE LEAK OR IS SPRAYED INTO THE AIR NEAR A CHLORINE LEAK, A WHITE FOG OF AMMONIA CHLORIDE FORMS. CARE SHOULD BE TAKEN TO AVOID SPRAYING AMMONIA WATER ON COPPER FITTINGS. PERSONNEL WEARING FULL FACEPIECE, SELF-CONTAINED BREATHING APPARATUS SHOULD POSITION THEMSELVES UP WIND SO ESCAPING CHLORINE MOVES AWAY FROM THEM. FOR LEAKS IN CYLINDERS AND TON CONTAINERS, ROTATE CYLINDER SO GAS ESCAPES INSTEAD OF LIQUID. IF POSSIBLE, REMOVE TO AN ISOLATED SPOT. EMERGENCY CAPPING KITS FOR CYLINDERS, TON CONTAINERS, TANK CARS, AND TANK TRUCKS INCLUDE STEP-BY-STEP INSTRUCTIONS AND TOOLS. A PPG TECHNICAL SERVICE BULLETIN CONTAINING COMPLETE INFORMATION ON THESE KITS IS AVILABLE.

CHLORINE CAN BE ABSORBED IN ALKALINE SOLUTIONS. COMMON SOLUTIONS ARE CAUSTIC SODA AND SODA ASH.

ALKALINE SOLUTIONS FOR CHLORINE ABSORPTION

CHLORINE CONTAINER SIZE	CAUSTIC SODA LB (100%)	CAUSTIC SODA WATER (GAL.)	SODA ASH LB	SODA ASH WATER (GAL.)
100 POUNDS	125	40	300	100
150 POUNDS	188	60	450	150
1 TON	2500	800	6000	2000

PLACE NEUTRALIZED MATERIAL IN A CLOSED CONTAINER. FOR GUIDANCE IN DISPOSAL OF NEUTRALIZED MATERIAL, CONTACT YOUR REGIONAL OFFICE OF THE ENVIRONMENTAL PROTECTION AGENCY (EPA). DO NOT DISCARD TO SEWER.

NOTE: CARE MUST BE TAKEN WHEN USING OR DISPOSING OF CHEMICAL MATERIALS AND/OR THEIR CONTAINERS TO PREVENT ENVIRONMENTAL CONTAMINATION. IT IS YOUR DUTY TO DISPOSE OF CHEMICAL MATERIALS AND/OR THEIR CONTAINERS IN ACCORDANCE WITH THE CLEAN AIR ACT, THE CLEAN WATER ACT, THE RESOURCE CONSERVATION AND RECOVERY ACT, AS WELL AS ANY OTHER RELEVANT FEDERAL, STATE OR LOCAL LAWS/REGULATIONS REGARDING DISPOSAL.

SECTION 8 - SPECIAL PROTECTION INFORMATION

RESPIRATORY PROTECTION:

USE NIOSH/MSHA APPROVED ACID GAS CARTRIDGE OR CANISTER RESPIRATOR FOR ROUTINE WORK PURPOSES WHEN CONCENTRATIONS ARE ABOVE THE PERMISSIBLE EXPOSURE LIMITS. USE FULL FACEPIECE RESPIRATORS WHEN CONCENTRATIONS ARE IRRITATING TO THE EYES. A CARTRIDGE-TYPE ESCAPE RESPIRATOR SHOULD BE CARRIED AT ALL TIMES WHEN HANDLING CHLORINE FOR ESCAPE ONLY IN CASE OF A SPILL OR LEAK. RE-ENTER AREA ONLY WITH NISOSH/MSHA APPROVED, SELF-CONTAINED BREATHING APPARATUS WITH FULL FACEPIECE. SEE SECTION 7 FOR RESPIRATORY PROTECTION DURING SPILLS OR LEAKS. THE RESPIRATOR USE LIMITATIONS SPECIFIED BY NIOSH/MSHA OR THE MANUFACTURER MUST BE OBSERVED. RESPIRATORY PROTECTION PROGRAMS MUST BE IN ACCORDANCE WITH 29 CFR 1910.134.

VENTILATION (TYPE):

USE GENERAL OR LOCAL EXHAUST VENTILATION SUFFICIENT TO MAINTAIN EMPLOYEE EXPOSURE TO CHLORINE BELOW PERMISSIBLE EXPOSURE LIMIT.

EYE PROTECTION:

CHEMICAL SPLASH-PROOF SAFETY GOGGLES

GLOVES:

LEATHER OR RUBBER

OTHER PROTECTIVE EQUIPMENT:

BOOTS, APRONS, AND CHEMICAL SUITS SHOULD BE WORN WHEN NECESSARY TO PREVENT SKIN CONTACT. PERSONAL PROTECTIVE CLOTHING AND USE OF EQUIPMENT MUST BE IN ACCORDANCE WITH 29 CFR 1910.132 AND 29 CFR 1910.133.

SECTION 9 - SPECIAL PRECAUTIONS

PRECAUTIONS TO BE TAKEN DURING HANDLING AND STORING:

* STORE IN WELL-MAINTAINED, FIREPROOF AREA AWAY FROM OTHER CONTAINERS.
* KEEP AWAY FROM HEAT AND MOISTURE! HEATING COULD MELT PLUGS ON CYLINDERS AND TON TANKS AND CAUSE SAFETY VALVES ON TANK CARS TO VENT, CAUSING LEAKS. MOISTURE (MORE THAN 150 PPM OF WATER) AND CHLORINE CAN FORM HYDROCHLORIC AND HYPOCHLOROUS ACIDS, WHICH ARE CORROSIVE.
* NEVER, PLACE A LEAKING CONTAINER IN WATER OR SPRAY LEAKING CONTAINER WITH WATER.
* MAKE SURE PIPING IS DRY AND FREE OF CONTAMINATION OF ANY TYPE BEFORE ADMITTING CHLORINE.
* USE ONLY DRY, OIL-FREE AIR (-40 F DEW POINT MINIMUM) OR OIL-FREE NITROGEN FOR PURGING, TESTING FOR LEAKS, OR PADDING.
* NEVER TAMPER WITH FUSIBLE PLUGS OR SAFETY DEVICES ON CONTAINERS; NEVER MANIFOLD CONTAINERS FROM LIQUID VALVES.

OTHER PRECAUTIONS:

* PERSONNEL NEAR OR HANDLING CHLORINE SHOULD AT ALL TIMES, CARRY A NIOSH/MSHA APPROVED CHEMICAL CARTRIDGE TYPE ESCAPE RESPIRATOR AND BE TRAINED IN ITS USE.
* AVOID BREATHING GAS!

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- USE WITH ADEQUATE VENTILATION! VENTILATION MUST BE SUFFICIENT TO LIMIT EMPLOYEE EXPOSURE AT OR BELOW PERMISSIBLE LIMITS.
- AVOID CONTACT WITH EYES, SKIN, AND CLOTHING! AT HIGH CONCENTRATIONS, CHLORINE IS CORROSIVE TO EYES, SKIN, AND MUCOUS MEMBRANES.
- PPG ONLY SHIPS CHLORINE IN BULK TANK CARS, TANK TRUCKS, AND BARGES. FOR ADDITIONAL HANDLING DETAILS, REFER TO PPG BROCHURE #506B.

COMMENTS:

TSCA - CHLORINE IS ON THE TSCA INVENTROY UNDER CAS NO. 7782-50-5.

SARA TITLE III - A) 311/312 CATEGORIES - ACUTE, REACTIVITY AND SUDDEN PRESSURE RELEASE, B) LISTED IN SECTION 313 UNDER CHLORINE, C) LISTED AS AN "EXTREMELY HAZARDOUS SUBSTANCE" IN SECTION 302.

CERCLA - LISTED IN TABLE 302.4 OF 40 CFR PART 302 AS A HAZARDOUS SUBSTANCE WITH A REPORTABLE QUANTITY OF 10 POUNDS. RELEASES TO AIR, LAND OR WATER WHICH EXCEED THE RQ MUST BE REPORTED TO THE NATIONAL RESPONSE CENTER, 800-424-8802.

NSF - PPG CHLORINE IS CERTIFIED FOR MAXIMUM USE AT 30 MG/L UNDER ANSI/NSF STANDARD 60.

CANADIAN WHMIS: SENSITIZATION TO PRODUCT - NONE KNOWN, B) REPRODUCTIVE TOXICITY - NONE KNOWN, C) ODOR THRESHOLD: 1 PPM, D) PRODUCT USE: WATER SANITIZATION, CHEMICAL REACTANT.

IN CASE OF EMERGENCY IN CANADA, CONTACT PPG CANADA, INC., B.P. 2010, BEAUHARNOIS, QUEBEC J6N 3C3, 514-429-3552, OR CANUTEC 613-996-6666.

REVISIONS MADE TO 8/12/93, 13TH EDITION: DATE, EDITION, ADDED TDG CANADA INFORMATION (PAGE 1) AND CANADIAN ADDRESS/PHONE NUMBERS (PAGE 8).

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SUPELCO, INC.

* ISSUE DATE
08/23/94 MATERIAL SAFETY DATA SHEET

SECTION I -GENERAL INFORMATION

* CATALOG NO
840042
* PRODUCT NAME
DICHLOROMETHANE 1000UG/ML 2X1ML
* DATA SHEET NO
840042
* SYNONYM
ANALYTICAL STANDARD IN METHANOL
DICHLOROMETHANE
FORMULA MIXTURE FORMULA WEIGHT
CAS NRTECS

SECTION II - HAZARDOUS INGREDIENTS OF MIXTURES
CHEMICAL NAME
COMMON NAME - PERCENTAGE - CAS #
(FORMULA) - PEL (UNITS) - TLV (UNITS)
LD50 VALUE - CONDITIONS

METHANOL
METHANOL 99.9 67-56-1
CH30H 260 MG/M3 262 MG/M3
5628 MG/KG ORAL RAT SEE FOOTNOTE (6)
METHANE, DICHLORO-
METHYLENE CHLORIDE 0.1 75-09-2
CH2C12 500 PPM 50 PPM
2524 MG/KG ORAL RAT SEE FOOTNOTE (3,6,8)

FOOTNOTES
3 CLASSIFIED BY IARC AS A CLASS 2B CARCINOGEN.
6 SUBJECT TO THE REPORTING REQUIREMENTS OF SARA TITLE III, SECTION 313.
8 CLASSIFIED BY NTP AS A GROUP B CARCINOGEN.

SECTION III - PHYSICAL DATA

BOILING POINT 65 C MM MELTING POINT -98 C
VAPOR PRESSURE 100 MM C VAPOR DENSITY 1.10 C (AIR=1)
SPECIFIC GRAVITY .790 G/ML C (WATER=1) PERCENT VOLATILE BY VOLU100
WATER SOLUBILITY 100 EVAPORATION RATE >1 (ETHER=1)
APPEARANCE CLEAR COLORLESS LIQUID

SECTION IV - FIRE AND EXPLOSION HAZARD DATA

FLASH POINT 50 F FLAMMABLE LIMITS LEL 6.0 36.5

EXTINGUISHING MEDIA

CO2
DRY CHEMICAL
ALCOHOL FOAM.

SPECIAL FIRE FIGHTING PROCEDURES

WEAR SELF CONTAINED BREATHING APPARATUS WHEN FIGHTING A CHEMICAL FIRE.

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SUPELCO, INC.

* ISSUE DATE
08/23/94 MATERIAL SAFETY DATA SHEET

* CATALOG NO
840042
* PRODUCT NAME
DICHLOROMETHANE 1000UG/ML 2X1ML
* DATA SHEET NO
840042
* SYNONYM
ANALYTICAL STANDARD IN METHANOL
DICHLOROMETHANE

SECTION IV - FIRE AND EXPLOSION HAZARD DATA

* CONTINUED *

UNUSUAL FIRE AND EXPLOSION HAZARDS

THE FOLLOWING TOXIC VAPORS ARE FORMED WHEN THIS MATERIAL IS HEATED TO DECOMPOSITION.
CARBON MONOXIDE, FORMALDEHYDE, PHOSGENE, HYDROGEN CHLORIDE.

SECTION V - HEALTH HAZARD DATA

LD50	5628	MG/KG	ORAL RAT	TLV 262	MG/M3
PEL	260	MG/M3			

EMERGENCY AND FIRST AID PROCEDURES

EYES
FLUSH EYES WITH WATER FOR 15 MINUTES
CONTACT A PHYSICIAN.

SKIN
FLUSH SKIN WITH LARGE VOLUMES OF WATER.
WASH CLOTHING AND SHOES BEFORE REUSING.

INHALATION
IMMEDIATELY MOVE TO FRESH AIR.
GIVE OXYGEN IF BREATHING IS LABORED
IF BREATHING STOPS, GIVE ARTIFICIAL RESPIRATION
CONTACT A PHYSICIAN

INGESTION
NEVER GIVE ANYTHING BY MOUTH TO AN UNCONSCIOUS PERSON
NEVER TRY TO MAKE AN UNCONSCIOUS PERSON VOMIT
GIVE 2 TABLESPOONS OF BAKING SODA IN A GLASS OF WATER
PRESS FINGERS TO BACK OF TONGUE TO INDUCE VOMITING.
IMMEDIATELY CONTACT A PHYSICIAN.

EFFECTS OF OVEREXPOSURE
HARMFUL IF INHALED
MAY BE FATAL IF SWALLOWED
CONTAINS MATERIAL (S) KNOWN TO THE STATE OF CALIFORNIA TO CAUSE CANCER.

* ISSUE DATE
08/23/94 MATERIAL SAFETY DATA SHEET

* CATALOG NO
840042
* PRODUCT NAME
DICHLOROMETHANE 1000UG/ML 2X1ML
* DATA SHEET NO
840042
* SYNONYM
ANALYTICAL STANDARD IN METHANOL
DICHLOROMETHANE

SECTION V - HEALTH HAZARD DATA

* CONTINUED *
LOW BLOOD PRESSURE (HYPOTENSION).
DERMATITIS
BREATHING DIFFICULTY
HEADACHE
NAUSEA
DIZZINESS
GASTROINTESTINAL DISTURBANCES
DEPRESSES CENTRAL NERVOUS SYSTEM
NARCOSIS
LIVER DAMAGE
KIDNEY DAMAGE
RESPIRATORY FAILURE
BLINDNESS
MAY CAUSE CORNEAL INJURY.

SECTION VI - REACTIVITY DATA

STABILITY STABLE.

CONDITIONS TO AVOID

N/A

INCOMPATIBILITY

STRONG ACIDS
OXIDIZING AGENTS
CHROMIC ANHYDRIDE, LEAD PERCHLORATE, PERCHLORIC ACIDS
ALUMINUM AND MAGNESIUM
METALS
HAZARDOUS DECOMPOSITION PRODUCTS
CARBON MONOXIDE, FORMALDEHYDE, PHOSGENE, HYDROGEN CHLORIDE

HAZARDOUS POLYMERIZATION WILL NOT OCCUR.

CONDITIONS TO AVOID

N/A

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* ISSUE DATE
08/23/94 MATERIAL SAFETY DATA SHEET

* CATALOG NO
840042
* PRODUCT NAME
DICHLOROMETHANE 1000UG/ML 2X1ML
* DATA SHEET NO
840042
* SYNONYM
ANALYTICAL STANDARD IN METHANOL
DICHLOROMETHANE

* CONTINUED *

SECTION VII - SPILL OR LEAK PROCEDURES

STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED

TAKE UP WITH ABSORBENT MATERIAL.
VENTILATE AREA.
ELIMINATE ALL IGNITION SOURCES.

WASTE DISPOSAL METHOD

COMPLY WITH ALL APPLICABLE FEDERAL, STATE, OR LOCAL REGULATIONS

SECTION VIII - SPECIAL PROTECTION INFORMATION

RESPIRATORY PROTECTION (SPECIFIC TYPE)

WEAR FACE MASK WITH ORGANIC VAPOR CANISTER.

PROTECTIVE GLOVES

WEAR RUBBER GLOVES.

EYE PROTECTION

WEAR PROTECTIVE GLASSES.

VENTILATION

USE ONLY IN WELL VENTILATED AREA.

SPECIAL

N/A

OTHER PROTECTIVE EQUIPMENT

N/A

SECTION IX - SPECIAL PRECAUTIONS

STORAGE AND HANDLING

REFRIGERATE IN SEALED CONTAINER.

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* SYNONYM
ANALYTICAL STANDARD IN METHANOL
DICHLOROMETHANE

SECTION IX - SPECIAL PRECAUTIONS

* CONTINUED *
KEEP AWAY FROM OXIDIZERS.
KEEP AWAY FROM IGNITION SOURCES.

OTHER PRECAUTIONS

AVOID EYE OR SKIN CONTACT.
AVOID BREATHING VAPORS.

WHILE THE INFORMATION AND RECOMMENDATIONS SET FORTH HEREIN ARE BELIEVED TO BE ACCURATE AS OF THE DATE HEREOF, SUPELCO, INC. MAKES NO WARRANTY WITH RESPECT THERETO AND DISCLAIMS ALL LIABILITY FROM RELIANCE THEREON.

LAST REVISED 2/25/93

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∗ ISSUE DATE
08/23/94 MATERIAL SAFETY DATA SHEET

SECTION I -GENERAL INFORMATION

* CATALOG NO
N09899
∗ PRODUCT NAME
PARATHION
* DATA SHEET NO
N09899
∗ SYNONYM
ANALYTICAL STANDARD IN METHYLENE CHLORIDE
PARATHION
FORMULA MIXTURE FORMULA WEIGHT
CAS NRTECS

SECTION II - HAZARDOUS INGREDIENTS OF MIXTURES

CHEMICAL NAME
COMMON NAME - PERCENTAGE - CAS #
(FORMULA) - PEL (UNITS) - TLV (UNITS)
LD50 VALUE - CONDITIONS

PHOSPHOROTHIOIC ACID, O, O-DIETHYL O- (4-NITROPHENYL) ESTER
PARATHION 0.02 56-38-2
C1OH14NO5PS 0.1 MG/M3 0.1 MG/M3
2 MG/KG ORAL RAT SEE FOOTNOTE (4, 6, 9)
METHANE, DICHLORO-
METHYLENE CHLORIDE 99-100 75-09-2
CH2C12 500 PPM 50 PPM
2524 MG/KG ORAL RAT SEE FOOTNOTE (3, 6, 8)

FOOTNOTES

3 CLASSIFIED BY IARC AS A CLASS 2B CARCINOGEN.
4 CLASSIFIED BY IARC AS A CLASS 3 CARCINOGEN.
6 SUBJECT TO THE REPORTING REQUIREMENTS OF SARA TITLE III, SECTION 313.
8 CLASSIFIED BY NTP AS A GROUP B CARCINOGEN.
9 THIS MATERIAL IS NOT LISTED ON THE TSCA (TOXIC SUBSTANCES CONTROL ACT) INVENTORY. THIS MATERIAL IS INTENDED FOR R&D USE ONLY AND MAY NOT BE USED FOR DRUG, HOUSEHOLD, OR OTHER PURPOSES. IT IS SUBJECT TO TSCA REGULATIONS AT CFR 40 PART 720.36 WHICH DEAL WITH THE EXEMPTION OF CHEMICALS USED IN RESEARCH AND DEVELOPMENT FROM PMN (PREMANUFACTURE NOTIFICATION) REQUIREMENTS. IN ADDITION, THE BURDEN OF SAFE USE OF THE MATERIAL RESTS WITH YOU AND, THEREFORE, IT SHOULD BE HANDLED ONLY BY QUALIFIED PERSONS TRAINED IN LABORATORY PROCEDURES AND GOOD SAFETY PRACTICES.

SECTION III - PHYSICAL DATA

BOILING POINT 40 C MM MELTING POINT -97 C
VAPOR PRESSURE 349 MM 2.0 C VAPOR DENSITY 2.93 20.0 C (AIR=1)
SPECIFIC GRAVITY 1.320 G/ML C (WATER=1) PERCENT VOLATILE BY VOLU100
WATER SOLUBILITY 1.6 EVAPORATION RATE 0.71 (ETHER=1)
APPEARANCE CLEAR COLORLESS LIQUID
ODOR ETHER-LIKE ODOR

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* CATALOG NO
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* PRODUCT NAME
PARATHION
* DATA SHEET NO
N09899
* SYNONYM
ANALYTICAL STANDARD IN METHYLENE CHLORIDE
PARATHION
* CONTINUED *

SECTION IV - FIRE AND EXPLOSION HAZARD DATA

FLASH POINT N/A FLAMMABLE LIMITS LEL 12.0 19.0

EXTINGUISHING MEDIA

WATER
CO2
DRY CHEMICAL

SPECIAL FIRE FIGHTING PROCEDURES

WEAR SELF CONTAINED BREATHING APPARATUS WHEN FIGHTING A CHEMICAL FIRE.

UNUSUAL FIRE AND EXPLOSION HAZARDS

THE FOLLOWING TOXIC VAPORS ARE FORMED WHEN THIS MATERIAL IS HEATED TO DECOMPOSITION.
HYDROGEN CHLORIDE & PHOSGENE.

SECTION V - HEALTH HAZARD DATA

LD50	2524	MG/KG ORAL RAT	TLV 50	PPM
PEL	500	PPM		

EMERGENCY AND FIRST AID PROCEDURES

EYES

FLUSH EYES WITH WATER FOR 15 MINUTES.

SKIN

PROMPTLY WASH SKIN WITH MILD SOAP AND LARGE VOLUMES OF WATER.
REMOVE CONTAMINATED CLOTHING.

INHALATION

IMMEDIATELY MOVE TO FRESH AIR.
GIVE OXYGEN IF BREATHING IS LABORED
IF BREATHING STOPS, GIVE ARTIFICIAL RESPIRATION
CONTACT A PHYSICIAN
NEVER ADMINISTER ADRENALIN FOLLOWING CH2C12 EXPOSURE.
INCREASED SENSITIVITY OF THE HEART TO ADRENALIN MAY BE CAUSED BY OVEREXPOSURE TO CH2C12.

INGESTION

NEVER GIVE ANYTHING BY MOUTH TO AN UNCONSCIOUS PERSON.

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* DATA SHEET NO
N09899
∗ SYNONYM
ANALYTICAL STANDARD IN METHYLENE CHLORIDE
PARATHION

SECTION V - HEALTH HAZARD DATA

* CONTINUED *
NEVER TRY TO MAKE AN UNCONSCIOUS PERSON VOMIT
DO NOT INDUCE VOMITING.
IMMEDIATELY CONTACT A PHYSICIAN.

EFFECTS OF OVEREXPOSURE

MAY BE FATAL IF INHALED
HARMFUL IF SWALLOWED
CONTAINS MATERIALS (S) KNOWN TO THE STATE OF CALIFORNIA TO CAUSE CANCER.
LACHRIMATION
IRRITATES SKIN
DEMATITIS
HEADACHE
DIZZINESS
NARCOSIS
LIVER DAMAGE
KIDNEY DAMAGE
SEVERAL CHRONIC INHALATION STUDIES REPORTED BY NIOSH REVEALED THAT TEST ANIMALS EXPOSED TO METHYLENE CHLORIDE CONCENTRATIONS AS HIGH AS 10,000PPM SHOWED SLIGHT LIVER & KIDNEY CHANGES. METHYLENE CHLORIDE HAS BEEN SHOWN TO INCREASE THE RATE OF SPONTANEOUSLY OCCURING MALIGNANT TUMORS IN ONE STRAIN OF LABORATORY MICE & BENIGN TUMORS IN LABORATORY RATS. OTHER ANIMAL STUDIES, AS WELL AS SEVERAL HUMAN EPIDEMIOLOGY STUDIES, HAVE INDICATED A NEGATIVE RESPONSE. METHYLENE CHLORIDE IS NOT BELIEVED TO POSE A CARCINOGENIC RISK TO MAN WHEN HANDLED AS RECOMMENDED. METHYLENE CHLORIDE IS LISTED IN GROUP 2B BY IARC & NOT LISTED BY NTP OR OSHA.
CH2CL2 IS METABOLIZED TO CO AND CAN STRESS THE CARDIOVASCULAR SYSTEM DUE TO INCREASED CARBOXYHEMOGLOBIN.
IN RATS METHYLENE CHLORIDE HAS BEEN SHOWN TO PRODUCE A SIGNIFICANT INCREASE IN SALIVARY GLAND TUMORS.

SECTION VI - REACTIVITY DATA

STABILITY STABLE.

CONDITIONS TO AVOID

N/A

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* PRODUCT NAME
PARATHION
* DATA SHEET NO
N09899
* SYNONYM
ANALYTICAL STANDARD IN METHYLENE CHLORIDE
PARATHION

SECTION VI - REACTIVITY DATA

* CONTINUED *

INCOMPATIBILITY

STRONG BASES
OXIDIZING AGENTS

HAZARDOUS DECOMPOSITION PRODUCTS

HYDROGEN CHLORIDE & PHOSGENE.

HAZARDOUS POLYMERIZATION WILL NOT OCCUR.

CONDITIONS TO AVOID

LIQUID OXYGEN OR OTHER STRONG OXIDANTS MAY FORM EXPLOSIVE MIXTURES WITH METHYLENE CHLORIDE.
THIS MATERIAL OR ITS VAPORS WHEN IN CONTACT WITH FLAMES, HOT GLOWING SURFACES OR ELECTRIC ARCS CAN DECOMPOSE TO FORM HYDROGEN CHLORIDE GAS AND TRACES OF PHOSGENE.

SECTION VII - SPILL OR LEAK PROCEDURES

STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED

TAKE UP WITH ABSORBENT MATERIAL.
VENTILATE AREA.
METHYLENE CHLORIDE VAPORS ARE HEAVIER THAN AIR AND WILL COLLECT IN LOW AREAS.

WASTE DISPOSAL METHOD

COMPLY WITH ALL APPLICABLE FEDERAL, STATE, OR LOCAL REGULATIONS

SECTION VIII - SPECIAL PROTECTION INFORMATION

RESPIRATORY PROTECTION (SPECIFIC TYPE)

WEAR FACE MASK WITH ORGANIC VAPOR CANISTER.

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* CATALOG NO
N09899
* PRODUCT NAME
PARATHION
* DATA SHEET NO
N09899
* SYNONYM
ANALYTICAL STANDARD IN METHYLENE CHLORIDE
PARATHION

SECTION VIII - SPECIAL PROTECTION INFORMATION

* CONTINUED *
WEAR NIOSH/OSHA APPROVED RESPIRATORY PROTECTION.

PROTECTIVE GLOVES

WEAR NEOPRENE GLOVES.

EYE PROTECTION

WEAR PROTECTIVE GLASSES.

VENTILATION

USE ONLY IN WELL VENTILATED AREA.

SPECIAL

N/A

OTHER PROTECTIVE EQUIPMENT

N/A

SECTION IX - SPECIAL PRECAUTIONS

STORAGE AND HANDLING

REFRIGERATE IN SEALED CONTAINER.

OTHER PRECAUTIONS

POSSIBLE CANCER HAZARD.

WHILE THE INFORMATION AND RECOMMENDATIONS SET FORTH HEREIN ARE BELIEVED TO BE ACCURATE AS OF THE DATE HEREOF, SUPELCO, INC. MAKES NO WARRANTY WITH RESPECT THERETO AND DISCLAIMS ALL LIABILITY FROM RELIANCE THEREON.

LAST REVISED 8/08/90

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10/24/93

MATERIAL SAFETY DATA SHEET

SECTION 1 - CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

THE LUBRIZOL CORPORATION
29400 LAKELAND BOULEVARD
WICKLIFFE, OHIO 44092
216/943-4200

This material is to be used for research purposes only under the supervision of a technically qualified individual. The toxicological properties may have not been completely characterized. To determine your responsibilities under the Toxic Substances Control Act (TSCA), please see the Regulatory Information Section.

PRODUCT TRADE NAME: 2005-1714

CAS NO: Confidential.
SYNONYMS: None.
GENERIC/CHEMICAL NAME: Gasoline
PRODUCT TYPE: Not applicable.
PREPARATION/REVISION DATE: 10/16/1993
TRANSPORTATION EMERGENCY PH NO (CHEMTREC): 1-800-424-9300

SECTION 2 - COMPOSITION/INFORMATION OF INGREDIENTS

- From 90 to 100 percent Gasoline, CAS no: 8006-61-9; OSHA PEL: 300.00 ppm; OSHA STEL: 500.00 ppm ACGIH TLV: 900.00 mg/cu M., 300.00 ppm; ACGIH TLV STEL: 1500.00 mg/cu M., 500.00 pppm;
- 33.0 percent Toluene, CAS no: 108-88-3; OSHA PEL: 100.00 ppm; OSHA STEL: 150.00 ppm ACGIH TLV: 375.00 mg/ cu M., 100.00 ppm; ACGIH TLV STEL: 560.00 mg/ cu M., 150.00 ppm PROPOSED TLV: 147.00 mg/cu M., 50.00 ppm (skin);
- 10.0 percent Xylene, CAS no: 1330-20-7; OSHA PEL: 435.00 mg/cu M., 100.00 ppm; OSHA STEL: 655.00 mg/cu M., 150.00 ppm ACGIH TLV:435.00 mg/ cu M., 100.00 ppm; ACGIH TLV STEL: 655.00 mg/cu M., 150.00 ppm;
- 5.0 percent Benzene, IARC Human Carcinogen, NTP Carcinogen, OSHA Carcinogen, CAS no: 71-43-2; OSHA PEL: 1.00 ppm; Lubrizol Recommended exposure level; TWA: 0.10 ppm; ACGIH TLV: 30.00 mg/cu M., 10.00 ppm; PROPOSED TLV: 0.30 mg/cu M., 0.10 ppm (skin); Lubrizol Recommended exposure level; TWA: 0.10 ppm;
- 4.0 percent 1, 2, 4-Trimethylbenzene, CAS no: 95-63-6;
- 3.0 percent Ethylbenzene, CAS no: 100-41-4; OSHA PEL: 100.00 ppm; OSHA STEL: 125.00 ppm ACGIH TLV; 435.00 mg/cu M., 100.00 ppm; ACGIH TLV STEL: 545.00 mg/ cu M., 125.00 ppm;

SECTION 3 - HAZARDS IDENTIFICATION

PRINCIPAL HAZARDS: DANGER

- EXTREMELY FLAMMABLE LIQUID AND VAPOR. VAPOR MAY CAUSE FLASH FIRE.
- CAUSES SEVERE IRRITATION TO THE EYES.
- HARMFUL IF INHALED.
- HARMUL IF ABSORBED THROUGH SKIN.
- MAY CAUSE SKIN IRRITATION.
- MAY CAUSE RESPIRATORY TRACT IRRITATION.
- CONTAINS COMPONENT (S) WHICH CAUSE CANCER.
- MAY CAUSE CHRONIC HEALTH EFFECTS. BASED ON DATA WITH LABORATORY ANIMALS.

See Section 11 for complete health hazard information.

SECTION 4 - FIRST AID MEASURES

ORAL:	DO NOT INDUCE VOMITING. If conscious, give 2 glasses of water. Get immediate medical attention.
EYE:	Flush immediately with water for at least 15 minutes. Get immediate medical attention.
SKIN:	Wash with soap and water. Immediately remove contaminated clothing. Get medical attention if irritation persists. Launder contaminated clothing before reuse and discard shoes and other leather articles saturated with the material.
INHALATION:	Remove exposed person to fresh air if adverse effects are observed. If breathing is labored, administer oxygen. If breathing has stopped, apply artificial respiration. If irritation persists or if toxic symptoms are observed, get medical attention.
ADDITIONAL:	Note to physician: Treat symptomatically.

SECTION 5 -FIRE FIGHTING MEASURES

FLASH POINT (Typical):	- 40 Deg C, -40 F (TCC)
UPPER FLAMMABLE LIMIT:	7.6 percent
LOWER FLAMMABLE LIMIT:	1.3 percent
EXTINGUISHING MEDIA:	CO2, dry chemical, alcohol foam. Water can be used to cool and protect exposed material.
SPECIAL FIREFIGHTING PROCEDURES:	Recommend wearing self-contained breathing apparatus. Water may cause splattering. Material will float on water.
UNUSUAL FIRE & EXPLOSION HAZARDS:	Toxic fumes, gases or vapors may evolve on burning. Vapors may be heavier than air and may travel along the ground to a distant ignition source and flash back. Container may rupture on heating.
AUTOIGNITION TEMPERATURE:	Not Determined.
EXPLOSION DATA:	Material does not have explosive properties.

SECTION 6 - ACCIDENTAL RELEASE MEASURES

SPILL PROCEDURES: May form explosive mixtures with air. Immediately evacuate all personnel from danger area. Personal Protective Equipment must be worn, see Personal Protection Section for PPE recommendations. Eliminate all sources of heat, sparks pilot lights, static electricity and open flames. Ventilate spill area. Shut off leak if without risk. Prevent entry into sewers and waterways. Pick up free liquid for recycle and/or disposal if can be accomplished safely with explosion proof equipment. Residual liquid can be absorbed on inert material. Check under Transportation and Labeling (DOT/CERCLA) and Other Regulatory Information Section (SARA) for hazardous substances to determine regulatory reporting requirements for spills.

SECTION 7 - HANDLING AND STORAGE

HANDLING PROCEDURES: Keep material away from heat, sparks, pilot lights, static electricity and open flame. Open container in a well ventilated area. Avoid breathing vapors. Keep containers closed when not in use. Wash thoroughly after handling. Launder contaminated clothing before reuse. Empty containers retain material residue. Do not cut, weld, braze, solder, drill, grind or expose containers to heat, flame, spark or other sources of ignition.

STORAGE PROCEDURES: Do not store near potential sources of ignition. Isolated outside storage is preferred. Inside storage area should be in a flammable liquids cabinet or storage area.

SECTION 8 - EXPOSURE CONTROLS/PERSONAL PROTECTION

VENTILATION PROCEDURE: Use local exhaust ventilation to control mists or vapors. Additional ventilation or exhaust may be required to maintain air concentrations below recommended exposure limits. Use explosion proof equipment.

GLOVES PROTECTION: Viton. Polyvinyl alcohol. Note: polyvinyl alcohol gloves are water soluble and should not be used when there is potential for water contact.

EYE PROTECTION: Faceshield.

RESPIRATORY PROTECTION: Use NIIOSH/MSHA approved full face respirator with a combination organic vapor and high efficiency filter cartridge if the recommended exposure limit is exceeded. Use self-contained breathing apparatus for entry into confined space, for other poorly ventilated areas and for large spill clean-up sites.

CLOTHING RECOMMENDATION: Long sleeve shirt is recommended. Wear a chemically protective apron when contact with material may occur. Use neoprene or nitrile rubber boots when necessary to avoid contaminating shoes. Do not wear rings, watches or similar apparel that could entrap the material and cause a skin reaction. Launder contaminated clothing before reuse.

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SECTION 9- PHYSICAL AND CHEMICAL PROPERTIES

VAPOR PRESSURE:	600 mm Hg at 20 Deg C
PH:	Not Determined.
SPECIFIC GRAVITY:	0.75 at 15.6 Deg C
WATER SOLUBILITY:	Insoluble.
PERCENT VOLATILE:	100
VAPOR DENSITY:	3 Air = 1
EVAPORATION RATE:	Not Determined.
ODOR:	Characteristic
APPEARANCE:	Clear colorless liquid
VISCOSITY:	Unknown.
ODOR THRESHOLD:	Unknown.
BOILING POINT:	32 Deg C, 89.6 Deg F (Initial)
FREEZING POINT:	Not Determined.
MOLECULAR WEIGHT:	Not Determined.

SECTION 10 - STABILITY AND REACTIVITY

STABILITY:	Material is normally stable at moderately elevated temperatures and pressures.
INCOMPATIBILITY:	Strong acids. Alkalis. Oxidizing agents. Halogens and halogenated compounds.
POLYMERIZATION;	Will not occur.
THERMAL DECOMPOSITION:	Smoke, carbon monoxide, aldehydes and other products of incomplete combustion.

SECTION 11 - TOXICOLOGICAL INFORMATION

-- ACUTE EXPOSURE --

ORAL TOXICITY: The LD50 in rats is > 5000 mg/Kg. Based on actual data. Swallowing this material causes irritation of mouth, esophagus and stomach, with nausea, vomiting, diarrhea and abdominal pain. Ingestion of this material may cause headache, dizziness, uncoordination, and general weakness.

EYE IRRITATION: Severe eye irritant. Based on actual data.

SKIN IRRITATION: May cause skin irritation. Based on actual data. Prolonged or repeated skin contact as from clothing wet with material may cause dermatitis. Symptoms may include redness, edema, drying, defatting and cracking of the skin.

DERMAL TOXICITY: Components of this material are absorbed through the skin.

INHALATION TOXICITY: The LC50 (1 hr.) in rats between 2 mg/l and 20 mg/l (200 ppm and 2000 ppm) in rats. TOXIC. Based on data from components or similar materials. High concentrations may cause headaches, dizziness, fatigue, nausea, vomiting, drowsiness, stupor, other central nervous system effects leading to visual impairment, respiratory failure, unconsciousness and death.

RESPIRATORY IRRITATION: May cause nose, throat, and lung irritation. Based on actual data.

DERMAL SENSITIZATION: No data available to indicate product or components may be a skin sensitizer.

INHALATION SENSITIZATION: No data available to indicate product or components may be respiratory sensitizer.

-- CHRONIC EXPOSURE --

CHRONIC TOXICITY: Repeated overexposure to toluene may cause loss of appetite, nose bleeding, liver enlargement, and kidney, spleen and lung damage. Repeated inhalation of hydrocarbon solvents such as toluene can cause chronic neurological disturbances. Xylene has been found to cause cardiac, liver and kidney effects, anemia and eye damage in laboratory animals. Prolonged and repeated inhalation of hydrocarbon solvents such as xylene can cause chronic neurological disturbances.

CARCINOGENICITY: Benzene is recognized as causing leukemia in humans. Gasoline has been shown to cause an increased rate of kidney tumors in laboratory animals. However, recent scientific data has shown this finding to be irrelevant to human risk assessment.

MUTAGENICITY: No data available to indicate product or any components present at greater than 0.1% are mutagenic or genotoxic.

REPRODUCTIVE TOXICITY: No data available to indicate either product or any components present at greater than 0.1% that may cause reproductive toxicity.

TERATOGENICITY: No data available to indicate product or any components contained at greater than 0.1% may cause birth defects.

SECTION 11 - TOXICOLOGICAL INFORMATION --- CONTINUED

-- ADDITIONAL INFORMATION --

OTHER: No other health hazards known.
EXPOSURE LIMITS: See Hazardous Ingredients Section for any applicable exposure limits for components.

SECTION 12 - ECOLOGICAL INFORMATION

FRESHWATER FISH TOXICITY: An environmental effects test program for freshwater fish is in progress.
FRESHWATER INVERTEBRATES TOXICITY: An environmental effects test program for freshwater invertebrates is in progress.
ALGAE TOXICITY: Environmental effects data for algae is not available on all materials.
SALTWATER FISH TOXICITY: Environmental effects data for saltwater fish is not available on all materials.
SALTWATER INVERTEBRATES: Environmental effects data for saltwater invertebrates is not available on all materials.
BACTERIA TOXICITY: An environmental effects test program for bacteria is in progress.
MISCELLANEOUS TOXICITY: Environmental effects data for flora and fauna is not available on all materials.
ENVIRONMENTAL FATE: An environmental effects test program for biodegradation is in progress.

SECTION 13 - DISPOSAL CONSIDERATIONS

WASTE DISPOSAL: Material, if discarded, is expected to be hazardous waste under RCRA due to ignitability and toxicity. Consider U.S. EPA RCRA Hazardous Waste Number D001 and its associated treatment standard.
If discarding this material, consider the possible relevance of the presence of the following chemicals and the treatment standards for the associated U.S. EPA RCRA Hazardous Waste Numbers:
33% Toluene, Cas no: 108-88-3, F005
10% Xylene, Cas no: 1330-20-7, F003
5.0% Benzene, Cas no: 71-43-2, D018.

SECTION 14 - TRANSPORT INFORMATION

U.S. DOT BULK SHIPPING DESCRIPTION:	Gasoline, Class 3, UN1203, PG II
U.S. DOT NON-BULK SHIPPING DESCRIPTION:	Gasoline, Class 3, UN1203, PG II
IMDG SHIPPING DESCRIPTION:	Gasoline, Class 3.1, UN1203, PG II
ICAO SHIPPING DESCRIPTION:	Gasoline, Class 3, UN1203, PG II
ADR/RID HAZARD CLASS:	3

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SECTION 15 - REGULATORY INFORMATION

U.S. TSCA INVENTORY:	All components of this material are on the US TSCA Inventory.
OTHER TSCA REG.:	Section 4a, 8d, 8a (Benzene, 1,2,4-trimethyl-). Section 8d, 8a (Ethylbenzene). Section 8d, 8a (Toluene). Section 8a (Xylene). May be subject to export notification under TSCA Section 12(b).
SARA EXT. HAZ. SUBST.:	This product does not contain greater than 1.0% of any chemical substance on the SARA Extremely Hazardous Substances list.
SARA SECTION 313:	3.0% Ethylbenzene, CAS no.: 100-41-4 33.0% Toluene, CAS no.: 108-88-3. 10.0% Xylene, CAS no.: 1330-20-7. 5.0% Benzene, CAS no.: 71-43-2 4.0% Benzene 1,2,4,-trimethyl-, CAS no.: 95-63-6
CERCLA HAZARDOUS SUBSTANCES:	None known.
CAL. PROP. 65:	This product contains the following chemical (s) known to the state of California to cause cancer and/or birth defects: 5.0% Benzene, CAS no.: 71-43-2 33.0% Toluene, CAS no.: 108-88-3
U.S. FUEL REGISTRATION:	Not applicable.
U.S. DEPT. OF AGRICULTURE:	This product has not been filed with the USDA to support H2 approvals.
FDA APPROVAL:	Not applicable.
EEC EINECS:	May require notification under EC Seventh Amendment Directive 92/32/EEC.
JAPAN MITI:	May require notification in Japan.
AUSTRALIA:	May require notification before sale under Australian regulations.
CANADA:	May require notification before sale under Canadian regulations.
CANADIAN FUEL REGISTRATION:	Not applicable.
AUSTRIA::	May require notification before sale under Austrian law.
SWITZERLAND:	May require notification before sale in Switzerland.
FINLAND:	May require notification before sale in Finland.
KOREA:	May require notification before sale in Korea.
KOREA FUEL REGISTRATION:	Not applicable,

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SECTION 16 - OTHER INFORMATION

NFPA CODE:	Health: 3	Fire: 4	Reactivity: 0
HMIS CODE	Health: 3	Fire: 4	Reactivity: 0

PRECAUTIONARY LABELS:

DANGER
- EXTREMELY FLAMMABLE LIQUID AND VAPOR. VAPOR MAY CAUSE FLASH FIRE.
- CAUSES SEVERE IRRITATION TO THE EYES.
- HARMFUL IF INHALED.
- HARMFUL IF ABSORBED THROUGH SKIN.
- MAY CAUSE SKIN IRRITATION.
- MAY CAUSE RESPIRATORY TRACT IRRITATION.
- CONTAINS COMPONENT (S) WHICH CAUSE CANCER.
- MAY CAUSE CHRONIC HEALTH EFFECTS. BASED ON DATA WITH LABORATORY ANIMALS.

REVISION INDICATORS: - This MSDS has no revisions since 09/13/93

The information presented herein has been compiled from sources considered to be dependable and is accurate to the best of The Lubrizol Corporation's knowledge; however, The Lubrizol Corporation makes no warranty whatsoever, expressed or implied, of MERCHANTABILITY OR FITNESS FOR THE PARTICULAR PURPOSE regarding the accuracy of such data or the results to be obtained from the use thereof. The Lubrizol Corporation assumes no responsibility for injury to recipient or to third persons or for any damage to any property and recipient assumes all such risks.

1 MALL 909
Mallinckrodt Chemical, Inc.
MONOCHLOROACETIC ACID
11/09/92
MONAC

MONOCHLOROACETIC ACID

Material Safety Data Sheet

Mallinckrodt Chemical, Inc.
P.O. Box 800
Paris, Kentucky 40362

Emergency Telephone Number
314-539-1600

Effective Date: 11-09-92 Supersedes 08-26-85

PRODUCT IDENTIFICATION:

Synonyms: Chloroacetic acid; chloroethanoic acid

Formula CAS No.: 79-11-8

Molecular Weight: 94.50

Hazardous Ingredients:
Monochloroacetic acid

Chemical Formula: CH2ClCOOH

PRECAUTIONARY MEASURES

DANGER! CORROSIVE. CAUSES SEVERE BURNS. HARMFUL IF SWALLOWED OR INHALED.

Do not get in eyes, on skin, or on clothing.
Do not breathe dust.
Keep container closed.
Use only with adequate ventilation.
Wash thoroughly after handling.

EMERGENCY FIRST AID

In all cases call a physician immediately. If swallowed, DO NOT INDUCE VOMITING! Give large quantities of water or milk if available. Never give anything by mouth to an unconscious person. If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. In case of contact, immediately flush eyes or skin with plenty of water for at least 15 minutes. SEE SECTION 5.

Physical Data SECTION 1

Appearance:	Colorless crystals or crystalline masses.	
Odor:	Penetrating, burning odor.	
Solubility:	Very soluble in water.	
Boiling Point:	189 C (372.2 F)	Vapor Density (Air=1): No information found.
Melting Point:	61 -63 C (141.8 -145.4 F)	Vapor Pressure (mm Hg): 10 @ 81 C (177.8 F)

1 MALL 909
Density: 1.580 Evaporation Rate: No information found.

Fire and Explosion SECTION 2
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Information

Fire:	As with most organic solids, fire is possible at elevated temperatures or by contact with an ignition source.
Explosion:	Not considered to be an explosion hazard.
Fire Extinguishing Media:	Water spray, dry chemical, alcohol foam, or carbon dioxide.
Special Information:	In the event of a fire, wear full protective clothing and NIOSH-approved self-contained breathing apparatus with full facepiece operated in the pressure demand or other positive pressure mode.

Reactivity Data SECTION 3
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Stability:	Stable under ordinary conditions of use and storage.
Hazardous Decomposition Products:	Oxides of carbon as well as ionic or oxidized halogen and phosgene.
Hazardous Polymerization:	This substance does not polymerize.
Incompatibilities:	Strong bases and oxidizing agents.

Leak/Spill Disposal Information SECTION 4
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Ventilate the area of the leak or spill. Clean-up personnel should wear protective clothing and respiratory equipment suitable for toxic for corrosive fluids or vapors. Sweep, scoop or pick up spilled material. Package unreclaimable material for disposal in a RCRA-approved waste facility. Flush area of spill with dilute soda ash solution.
Reportable Quantity (RQ) (CWA/CERCLA): 1 lb.
Ensure compliance with local, state and federal regulations.

Health Hazard Information SECTION 5
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A. Exposure/Health Effects

Inhalation:	Toxic, corrosive. Dust can cause serious irritation of the respiratory tract and lung edema. Coughing, sneezing and shortness of breath are the usual symptoms; absorption of the acid through the lungs can produce the symptoms listed under Ingestion, below.

1 MALL 909

Ingestion:	Corrosive. Causes sore throat, abdominal pain, vomiting and, perhaps convulsions and death. Mucous membrane can be corroded or burned.
Skin Contact:	Substance is a corrosive irritant and can form lesions on continued contact.
Eye Contact:	Corrosive to the eye. Causes redness, pain, blurred vision and possible destruction of tissue.
Chronic Exposure:	Liver and kidney dysfunctions have been reported.
Aggravation of Pre-existing Conditions:	Persons with pre-existing skin disorders or eye problems or impaired liver or kidney function may be more susceptible to the effects of the substance.

B. FIRST AID

Inhalation:	Remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Call a physician.
Ingestion:	DO NOT INDUCE VOMITING! Give large quantities of water or milk if available. Never give anything by mouth to an unconscious person. Get medical attention immediately.
Skin Exposure:	In case of contact, immediately flush skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Wash clothing before reuse. Call a physician immediately.
Eye Exposure:	Wash eyes with plenty of water for at least 15 minutes, lifting lower and upper eyelids occasionally. Get medical attention immediately.

C. TOXICITY (RTECS, 1992)

Oral rat LD50: 580 mg/kg; inhalation rat LC50: 180 mg/m3; investigated as a tumorigen, mutagen.

Occupational Control Measures SECTION 6
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Airborne Exposure Limits:	None established.
Ventilation System:	A local exhaust system which captures the contaminant at its source is recommended to prevent dispersion of the contaminant into the workroom air.
Personal Respirators (NIOSH Approved)	For conditions of use where exposure to the dust is apparent, a dust/mist respirator may be worn. For emergencies, a self-contained breathing apparatus may be necessary.

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Skin Protection:	Wear impervious protective clothing, including boots, gloves, lab coat, apron or coveralls, as appropriate, to prevent skin contact.
Eye Protection:	Use chemical safety goggles. Contact lenses should not be worn when working with this material. Maintain eye wash fountain and quick-drench facilities in work area.

Storage and Special Information SECTION 7
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Keep in a tightly closed container. Store in a cool, dry, ventilated area away from sources of heat or ignition. Protect against physical damage.

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MONAC

Addendum to Material Safety Data Sheet

REGULATORY STATUS

This Addendum Must Not Be
Detached from the MSDS
Identifies SARA 313 substance (s)

Any copying or redistribution of the MSDS
must include a copy of this addendum

Hazard Categories for SARA
Section 311/312 Reporting

Acute	Chronic	Fire	Pressure	Reactive
X				

	SARA EHS		SARA Sec. 313 Chemicals		CERCLA	RCRA
Product or Components of Product:	Sec. RQ	302 TPQ	Name List	Chemical Category	Sec. 103 RQ lbs.	Sec. 261.33
MONOCHLOROACETIC ACID (79-11-8)	1	100*	Yes	No	1	No

SARA Section 302 EHS RQ:
Reportable Quantity of Extremely Hazardous Substance, listed at 40 CFR 355.

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SARA Section 302 EHS TPQ:
Threshold Planning Quantity of Extremely Hazardous substance. An asterisk (*) following a Threshold Planning Quantity signifies that if the material is a solid and has a particle size equal to or larger than 100 micrometers, the Threshold Planning Quantity = 10,000 LBS.

SARA Section 313 Chemicals:
Toxic Substances subject to annual release reporting requirements listed at 40 CFR 372.65.

CERCLA Sec. 103:
Comprehensive Environmental Response, Compensation and Liability Act (Superfund) Releases to air, land or water of these hazardous substances which exceed the Reportable Quantity (RQ) must be reported to the National Response Center, (800-424-8802); Listed at 40 CFR 302.4

RCRA:
Resource Conservation and Recovery Act. Commercial chemical product wastes designated as acute hazards or toxic under 40 CFR 261.33

MONAC

MONOCHLOROACETIC ACID

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SUPELCO, INC.

* ISSUE DATE
08/23/94 MATERIAL SAFETY DATA SHEET

SECTION I - GENERAL INFORMATION

* CATALOG NO
R427340
* PRODUCT NAME
2, 4-D
* DATA SHEET NO
R427340
* SYNONYM
2, 4-DICHLOROPHENOXY-ACETIC ACID
2, 4-D
CHEMICAL NAME ACETIC ACID, (2, 4-DICHLOROPHENOXY)-
FORMULA C8H6CLO3 FORMULA WEIGHT 185
CAS 94-75-7 NRTECS AG6825000
SUBJECT TO THE REPORTING REQUIREMENTS OF SARA TITLE III, SECTION 313

SECTION II - HAZARDOUS INGREDIENTS OF MIXTURES

CHEMICAL NAME
COMMON NAME - PERCENTAGE - CAS #
(FORMULA) - PEL (UNITS) - TLV (UNITS)
LD50 VALUE - CONDITIONS

SECTION III - PHYSICAL DATA

BOILING POINT N/A MELTING POINT 140 C
VAPOR PRESSURE 0 MM C VAPOR DENSITY 7.63 C (AIR=1)
SPECIFIC GRAVITY 1.1 G/ML C (WATER=1) PERCENT VOLATILE BY VOLU0
WATER SOLUBILITY 0.07 EVAPORATION RATE N/A
APPEARANCE CLEAR COLORLESS LIQUID
ODOR ODORLESS

SECTION IV - FIRE AND EXPLOSION HAZARD DATA

FLASH POINT N/A FLAMMABLE LIMITS LEL N/A
N/A

EXTINGUISHING MEDIA

CO2
DRY CHEMICAL
ALCOHOL FOAM.

SPECIAL FIRE FIGHTING PROCEDURES

WEAR SELF CONTAINED BREATHING APPARATUS WHEN FIGHTING A CHEMICAL FIRE.

UNUSUAL FIRE AND EXPLOSION HAZARDS

THE FOLLOWING TOXIC VAPORS ARE FORMED WHEN THIS MATERIAL IS HEATED TO DECOMPOSITION.
HCL

SUPELCO, INC.

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2, 4-D

SECTION V - HEALTH HAZARD DATA

LD50 375 MG/KG ORAL RAT TLV 10 MG/M3
PEL 10 MG/M3

EMERGENCY AND FIRST AID PROCEDURES
EYES

FLUSH EYES WITH WATER FOR 15 MINUTES.

SKIN
PROMPTLY WASH SKIN WITH MILD SOAP AND LARGE VOLUMES OF WATER.

INHALATION
IMMEDIATELY MOVE TO FRESH AIR.
GIVE OXYGEN IF BREATHING IS LABORED

INGESTION
NEVER GIVE ANYTHING BY MOUTH TO AN UNCONSCIOUS PERSON
NEVER TRY TO MAKE AN UNCONSCIOUS PERSON VOMIT
GIVE LARGE AMOUNTS OF WATER
PRESS FINGERS TO BACK OF TONGUE TO INDUCE VOMITING.

EFFECTS OF OVEREXPOSURE

WEAKNESS
LETHARGY
CONVULSIONS

SECTION VI - REACTIVITY DATA

STABILITY STABLE.

CONDITIONS TO AVOID

N/A

INCOMPATIBILITY

OXIDIZING AGENTS

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2, 4-D

SECTION VI - REACTIVITY DATA

* CONTINUED*

HAZARDOUS DECOMPOSITION PRODUCTS

HCL

HAZARDOUS POLYMERIZATION WILL NOT OCCUR.

CONDITIONS TO AVOID

N/A

SECTION VII - SPILL OR LEAK PROCEDURES

STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED

TAKE UP WITH ABSORBENT MATERIAL.
VENTILATE AREA.

WASTE DISPOSAL METHOD

COMPLY WITH ALL APPLICABLE FEDERAL, STATE, OR LOCAL REGULATIONS

SECTION VIII - SPECIAL PROTECTION INFORMATION

RESPIRATORY PROTECTION (SPECIFIC TYPE)

WEAR NIOSH/OSHA APPROVED RESPIRATORY PROTECTION.

PROTECTIVE GLOVES

WEAR GLOVES.

EYE PROTECTION

WEAR PROTECTIVE GLASSES.

VENTILATION

USE ONLY IN WELL VENTILATED AREA.

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2, 4-D

* CONTINUED *

SECTION IX - SPECIAL PRECAUTIONS

SPECIAL

N/A

OTHER PROTECTIVE EQUIPMENT

N/A

STORAGE AND HANDLING

STORE IN SEALED CONTAINER IN COOL, DRY LOCATION.
KEEP AWAY FROM OXIDIZERS.
AVOID GENERATING DUST.

OTHER PRECAUTIONS

AVOID EYE OR SKIN CONTACT.

WHILE THE INFORMATION AND RECOMMENDATIONS SET FORTH HEREIN ARE BELIEVED TO BE ACCURATE AS OF THE DATE HEREOF, SUPELCO, INC. MAKES NO WARRANTY WITH RESPECT THERETO AND DISCLAIMS ALL LIABILITY FROM RELIANCE THEREON.

LAST REVISED 3/30/94

MATERIAL SAFETY DATA SHEET Page 1 of 6

RHONE-POULENC PRODUCT NAME (S)	PRODUCT CODE(S)
2,4-DICHLOROPHENOL	3-1297-00

RHONE-POULENC INC.
P.O. Box 125, Black Horse Lane
Monmouth Junction, NJ 08852
(201) 297-0100

Emergency Phone Number (24 Hours)
CHEMTREC 800-424-9300

Date Prepared	Supercedes
11/4/87	11/2/86
	MSDS Number
	00182-26.ORG

Section 1. PRODUCT IDENTIFICATION

Synonym (s): 2,4-Dichlorophenol: DCP

Chemical Name(s) of Primary Component(s)	CAS Number(s)	Chemical Formula
2,4-Dichlorophenol	120-83-2	C_6H_4ClO

Section 2. INGREDIENTS/SUMMARY OF HAZARDS

Ingredients(s)	CAS Number(s)	OSHA Hazardous (H)/ Non-Hazardous (NH)	Percent
2,4-Dichlorophenol	120-83-2	H	>98.5

SARA Title III Hazard Classification:

(X) Immediate (Acute) Health Hazard
( ) Delayed (Chronic) Health Hazard
( ) Fire Hazard
( ) Sudden Release of Pressure Hazard
( ) Reactive Hazard

WARNING STATEMENT:

HIGHLY TOXIC BY INHALATION. TOXIC BY INGESTION AND SKIN ABSORPTION. CORROSIVE TO SKIN, EYES AND METAL. ADVERSE CENTRAL NERVOUS SYSTEM EFFECTS.

Section 3. PHYSICAL DATA

Melting Point (º F):	113
Boiling Point (º F):	410
Vapor Pressure (mHg at 53º C):	1
Vapor Density (air=1):	5.6
Solubility in Water:	Slightly soluble

MATERIAL SAFETY DATA SHEET Page 2 of 6

RHONE-POULENC PRODUCT NAME (S)
2,4-DICHLOROPHENOL

Section 3. PHYSICAL DATA (Continued)

Specific Gravity:	1.383 @ 50º C
Evaporation Rate (butyl acetate=1):	Not available
% Volatile by Volume:	Not available
Appearance/Odor:	White to rose solid/phenol-like

Section 4. FIRE AND EXPLOSION HAZARD DATA

Flash Point (º F)/Method: 235/TCC

Flammable Limits:	LFL	Not available	UFL	Not available

Extinguishing Media:
(X) Water Fog (X) Foam
(X) Dry Chemical (X) CO_2
( ) Other (specify):

Special Fire Fighting Procedures:
Wear a NIOSH/MSHA approved self-contained breathing apparatus and full protective clothing. Cool containers exposed to fire with water.

Unusual Fire and Explosion Hazards:
CORROSIVE TO EYE, SKIN AND METAL. TOXIC MATERIAL. Toxic fumes emitted on combustion.

Section 5. REACTIVITY DATA

Stability: ( ) Unstable (X) Stable

Conditions to avoid: Heat and open flame.

Incompatibility (materials to avoid):
( ) Water ( ) Strong acids (X) Strong bases
( ) Reducing agents (X) Strong oxidizing materials ( ) Combustible materials
(X) Other (specify): Acid chlorides, acid anhydrides.

Hazardous Decomposition Products or Byproducts:
At decomposition temperatures, hydrogen chloride, phenol and oxides of carbon are emitted.

RHONE-POULENC PRODUCT NAME (S)
2,4-DICHLOROPHENOL

Section 5. REACTIVITY DATA (Continued)

Hazardous polymerization: ( ) May occur (X) Will not occur

Conditions to avoid: Not applicable

Section 6. HEALTH HAZARD DATA/FIRST AID PROCEDURES

EXPOSURE LIMITS IN AIR (TLV or suggested control figure)

No TLV established for product.

EFFECTS OF SINGLE OVEREXPOSURE

Swallowing:	TOXIC BY MOUTH. Acute oral LD50: 580 mg/kg (rat); 1276 mg/kg (mouse); 464 mg/kg (mammal). (2)
Skin Absorption:	TOXIC BY SKIN ABSORPTION. Acute dermal LD50: 790 mg/kg (mammal). (2)
Inhalation:	HIGHLY TOXIC BY INHALATION. Powder is an extreme respiratory irritant. See NOTE TO PHYSICIAN for symptoms. Inhalation/rat LC50: 0.97 mg/1/4H. (3)
Skin Contact:	CORROSIVE. Will cause phenol-like burns to skin.
Eye Contact:	CORROSIVE. Will cause phenol-like burns and irreversible eye damage.

EFFECTS OF REPEATED OVEREXPOSURE:
Central nervous system problems such as motor weakness, increased respiration, tremors, convulsions.

CARCINOGENICITY:
This product does not contain any ingredient designated by IARC, NTP, ACGIH or OSHA as a probable human carcinogen.

SIGNIFICANT LABORATORY DATA WITH POSSIBLE RELEVANCE TO MAN: No additional data found.

MEDICAL CONDITIONS AGGRAVATED BY OVEREXPOSURE:
Central nervous system problems, respiratory disease.

RHONE-POULENC PRODUCT NAME (S)
2,4-DICHLOROPHENOL

Section 6. HEALTH HAZARD DATA/FIRST AID PROCEDURES (Continued)

FIRST AID PROCEDURES

EYES: IMMEDIATELY, flush eye and surrounding skin with a large volume of water using an eye-wash fountain for at least 15 minutes. Thoroughly rinse under lids. GET IMMEDIATE MEDICAL ATTENTION, PREFERABLY AN EYE DOCTOR.

SKIN: IMMEDIATELY, wash with a large volume of water and soap for at least 15 minutes. Remove contaminated clothes and shoes under shower. SEE NOTE TO PHYSICIAN FOR FURTHER FIRST AID. GET IMMEDIATE MEDICAL ATTENTION.

INHALATION:

Wear appropriate protective gear. Remove victim from area of exposure. Give oxygen therapy. If breathing stopped, give artificial respiration. GET IMMEDIATE MEDICAL ATTENTION. SEE NOTE TO PHYSICIAN.

INGESTION:

GET IMMEDIATE MEDICAL ATTENTION. SEE NOTE TO PHYSICIAN. If conscious, give a large volume of vegetable oil.

NOTE TO PHYSICIAN:

This material is highly toxic by inhalation and toxic by skin absorption and ingestion. It produces central nervous system problems that manifest themselves by such symptoms as motor weakness, increased respiration, tremors, and convulsions. It is also a strong irritant and can cause phenol-like burns.

EYES

Flush eye and surrounding skin with a large volume of water. Treat as for phenol burns. Consult an ophthalmologist.

SKIN

Immediately, wash all exposed skin with a large volume of water or isopropyl alcohol. Treat as for phenol burns. We have used the following PVP Treatment successfully to minimize the effects of skin contact with and to reduce absorption through the skin of phenol-like materials:

> PVP (polyvinylpyrrolidone) Treatment. Either apply directly a water paste of PVP or neutralizing solution of 40 grams PVP, 1/2 gallon water and 1/2 gallon isopropyl alcohol.
>
> For contact over 10% of body, treat by removing clothes and shoes under a shower and then wrapping in PVP-soaked towels. Transport to hospital for observation and further treatment.
>
> Keep a supply of PVP solution on hand. PVP is manufactured by GAF Corporation, Chemical Division.

Section 6. HEALTH HAZARD DATA/FIRST AID PROCEDURES (Continued)

NOTE TO PHYSICIAN (Continued):

INGESTION (1)
If conscious, give olive oil and then induce vomiting. If vomiting is not induced, gastric lavage with milk or water. DO NOT USE ALCOHOL. Leave some olive oil to coat stomach lining. Stomach tube and emetics may be contraindicated if corrosion is evident.

Administer milk, egg albumin, egg white, or olive oil as demulcents. Maintain victim in recumbent position. Apply external heat to keep warm. Keep victim quiet. Give fluids to restore electrolyte balance. Morphine may be given for pain. Treat shock if indicated. Sodium sulfate as a purgative--15 grams in a glass of warm water. Stimulants PRN, especially for CV embarrassment. Treat liver and kidney damage if indicated. Give antibiotics, oxygen and artificial respiration if indicated.

INHALATION
Give oxygen therapy. If breathing stopped, give artificial respiration. Treat symptomatically as for phenol inhalation.

Section 7. PRECAUTIONS FOR SAFE HANDLING AND USE

STEPS TO BE TAKEN IF MATERIAL IS RELEASED OR SPILLED:
Isolate area. Wear appropriate protective gear. Sweep up into steel drum. Avoid creating dusting conditions. Ventilate area. Clean up residue with a 2-5% solution of soda ash.

WASTE DISPOSAL METHOD:
Dispose of in accordance with Local, State and Federal regulations.

HANDLING AND STORAGE:
HIGHLY TOXIC BY INHALATION. TOXIC BY INGESTION AND SKIN ABSORPTION. CORROSIVE TO SKIN, EYES AND METALS. Store in a cool, dry place in tightly closed containers. Avoid direct exposure to sun. Avoid breathing dusts. Avoid direct exposure with skin and eyes. Product should be handled in a closed building or tank equipped with alkali scrubber. Wash hands thoroughly after handling. Do not rub eyes with soiled hands. Do not eat, drink or smoke in the work area. Avoid plastic materials like polystyrene.

OTHER PRECAUTIONS:
Runoff from fire control may cause pollution.

MATERIAL SAFETY DATA SHEET Page 6 of 6

RHONE-POULENC PRODUCT NAME (S)
2,4-DICHLOROPHENOL

Section 8 CONTROL MEASURES AND WORKER PROTECTION INFORMATION

Respiratory Protection (specify type):
Use a NIOSH/MSHA approved air purifying respirator with appropriate cartridge for phenol-like compounds.

Ventilation:
Provide adequate ventilation. Use local exhaust.

Protective Clothing:
Work uniform, gloves and boots.

Eye Protection:
( ) Safety Glasses with Side Shields
( ) Chemical Workers Goggles
(X) Gas-tight Goggles or Equivalent
(X) Other (specify): DO NOT WEAR CONTACT LENSES. Use a face shield.

Other Protective Equipment:
Maintain a sink, safety shower, eyewash fountain, oxygen and PVP solution (see NOTE TO PHYSICIAN) in the work area.

Section 9. REGULATORY STATUS

TSCA Inventory Status: Product is TSCA certified. Subject to TSCA test rule.

Transportation Status: RQ, Chlorophenols, solid, Class 6.1 Poison UN 2020 (2,4-dichlorophenol)

Reportable Quantity (RQ), under U.S. EPA CERCIA: RQ 100 lb.

Specifically Listed under SARA Title III
( ) Section 302 Extremely Hazardous Substances
(X) Section 313 Toxic Chemicals

Section 10. REFERENCES

(1) Handbook of Emergency Toxicology, Phenols, Sidney Kay (1976).
(2) RTEC (4/87) SK8575000.
(3) Unpublished Rhone-Poulenc sponsored toxicity study.

The information herein is given in good faith but no warranty, expressed or implied, is made.

APPENDIX B

ANATOMY AND PHYSIOLOGY REVIEW

PHYSIOLOGY AND THE INTERNAL ENVIRONMENT

Physiology is the study of function in living matter. Of course, human physiology deals with the function of humans. It attempts to explain why life exists and deals with chemical reactions that occur within the cells, the transmission of nerve impulses, contraction of muscles, reproduction, and other chemical and physical phenomena. In order to understand the toxic event, it is necessary to understand what is supposed to be going on normally, in the absence of chemical poisoning.

The human being is, in many ways, an automaton. Many of the basic functions that allow us to live are automatic. In addition, the human species is able to survive under widely varying conditions. There are people living on the equator and people living in Antarctica, people living at sea-level and on mountains. Furthermore, people can travel from one environment to another and adapt very quickly to the change. The physiological changes that occur tend to occur quickly and without conscious effort. This ability to adapt and to function automatically is a result of what is going on at the level of the individual cell.

THE RESPIRATORY SYSTEM

Oxygen is required for the cell to live. The oxygen is supplied to the cells by the blood. Respiration can be divided into four areas: 1) pulmonary ventilation; 2) diffusion of oxygen and carbon dioxide between the alveoli and the blood; 3) transport of oxygen and carbon dioxide to and from cells; and 4) the regulation of ventilation. The focus here will be on respiratory anatomy and pulmonary ventilation.

The nasal cavity consists of nostrils fringed with coarse hair. The function of the hair is to strain out the large particles and possibly to prevent the invasion of insects. The nasal septum divides the nose into right and left halves. Inside the nostrils are irregular structures called conchae. The purpose of these projections is to increase the surface area within the nostrils. This in turn assists in warming the air, hydrating the air and creating turbulence. The nasal cavity also is lined with epithelial cells which should be moist under normal conditions. An abundance of mucous glands provides the moisture. The epithelial cells are of the ciliated variety.

TURBULENCE

The primary reason that turbulence is needed in the nostrils is to help filter out large particles that the hairs didn't catch. As the particles are thrown against the sides of the nostrils, they become trapped in the mucous and are moved backwards by the cilia until they reach the rear of the nostrils where they are "dripped" into the nasopharynx. The average person swallows over a pint of this dirty mucous a day. This process can be interrupted if the cilia become irritated or damaged. The nostrils are also a very vascular place, due to the need for hydration and warming.

THE PHARYNX

The pharynx or throat consists of three regions: the nasopharynx, the oropharynx, and the laryngopharynx. The nasopharynx lies just behind the internal nares, or just to the rear of the inside of the nose. The oropharynx lies just below the nasopharynx and the laryngopharynx surrounds the openings of the larynx and the esophagus. The larynx is located at the top of the trachea in close proximity to the esophagus.

During swallowing, the larynx actually elevates and gets covered by the epiglottis to prevent the entry of food or liquid into the trachea. Among the functions of the larynx are protecting the trachea, keeping air from entering and leaving during periods of high thoracic pressure, and producing voice.

THE TRACHEA

The trachea or windpipe and the tracheobronchial tree are the next structure below the larynx. The trachea is a thin-walled tube about the diameter of a garden hose. It is made of tough connective tissue enclosed by incomplete rings of cartilage. The cartilage serves to keep the trachea from collapsing.

The Bronchi

The trachea branches into two main bronchi. The bronchi are structurally similar to the trachea and they branch off into successively smaller openings. There is less and less cartilage as the bronchus gets smaller, lending less and less structural support. These bronchial passages eventually terminate in the bronchioles.

The Lungs

The lungs are divided into large segments called lobes. The lungs are elastic, spongy organs and each is covered by a thin layer of tissue called the pleura. This tissue also lines the inside of the chest wall and is what allows the lungs to "glide" as they expand and contract. A good example of how these pleural layers work is the interaction of two pieces of wet plastic wrap. They are fairly easy to move against one another in a sliding motion, but are difficult to pull apart.

There is a potential space between these layers of pleura called the pleural space.

Another important feature of the lungs is the presence of surfactant. The surfactant is a detergent-like material that allows the lungs to expand. It also allows for the diffusion of gases within the lung by lowering the surface tension of the moisture present.

The bronchioles mentioned earlier actually end up in structures called the terminal respiratory units. The respiratory bronchioles that branched off from the bronchi terminate in the terminal bronchioles. These terminal bronchioles contain no mucous or cilia and they themselves end in the alveoli. The terminal bronchioles and the alveoli together make up the terminal respiratory units. Each terminal bronchiole branches about three to five times before entering a cluster of alveoli. Most of the gas exchange takes place in the alveoli, but there is some exchange taking place in the terminal bronchioles.

The Alveoli

The alveoli are composed of thin epithelium with elastic fibers. This allows for expansion of the alveoli as they fill with air. The walls of the alveoli are only one cell thick and contain the most extensive capillary bed in the body. There are many macrophages present in the alveoli as well as special secretor cells for the manufacturing of surfactant. Cells with secretion duties tend to be rich in this special type of membrane within the cell. Another often-overlooked function of the alveoli, with their abundance of macrophages, is the ingestion of normally occurring blood clots that end up in the lungs.

MEDICAL IMPLICATIONS

The respiratory system is an important system to understand for the medical responder at fire and hazardous materials scenes. This system is in direct, constant contact with the outside environment and presents an extremely vulnerable part of the body for the entry of toxins into the body. A thorough understanding of the structure and function of the respiratory tree is critical for the responder to be able to deal safely with the threat to this vital bodily function.

THE NERVOUS SYSTEM

The nervous system is the body's link to the outside world. In addition to keeping the body in touch with the outside world, it also allows for appropriate responses to those external stimuli. The nervous system also helps direct complex activities in the internal environment. The nervous system acts in conjunction with the endocrine or glandular system to maintain homeostasis. Homeostasis is the physiological balance produced by the equilibrium of functions and chemical composition within an organism. It is explained in greater detail later, in the discussion of the cell. The nervous system is by far the most complex of all the bodily systems. Therefore this discussion will be only a rapid review.

TWO MAIN DIVISIONS

The nervous system has two main divisions, the central nervous system and the peripheral nervous system. The central nervous system consists of the brain and spinal cord and serves as the control center of the organism. The central nervous system integrates incoming information, determines the appropriate response, and transmits the needed messages out to the appropriate organs to effect the response.

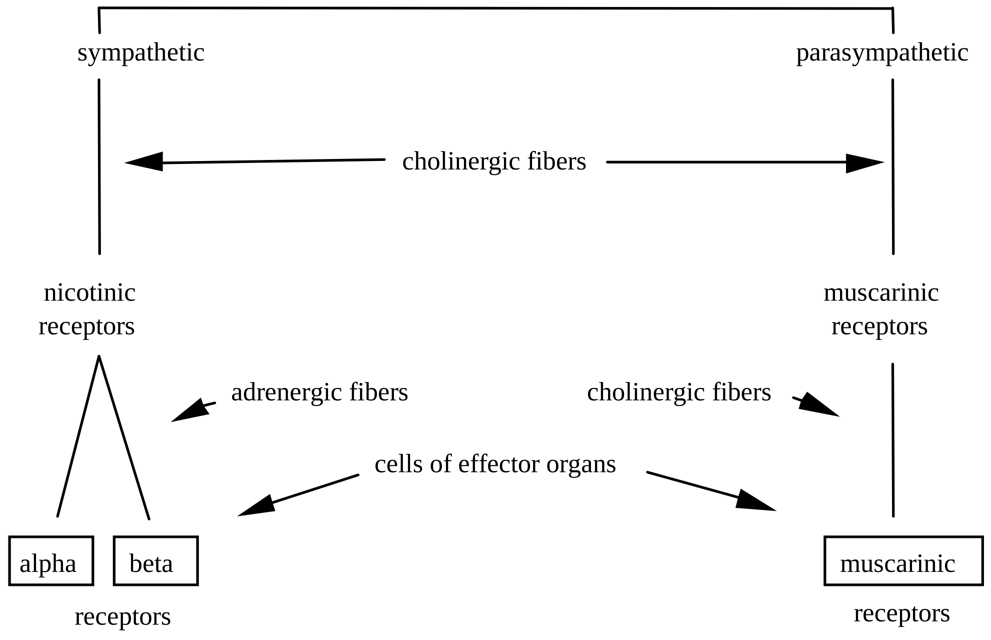
The peripheral nervous system consists of sensory receptors and the nerves that serve as communications lines for the central nervous system. There are 12 pairs of cranial nerves that go directly to the brain and 31 pairs of spinal nerves that "connect in" at the spinal cord. These sensors and nerves continually keep the central nervous system abreast of what is going on around and in the body. When the brain makes a decision, the peripheral nerves relay the orders to carry out that decision.

TYPES OF NERVES

Within the peripheral nervous system there are two types of nerves, the somatic and the autonomic. The somatic nerves are connected with activities that deal with the external environment. There are two types of somatic nerves, the sensory, or afferent nerves, and the motor, or efferent nerves. The titles are self-explanatory.

Within the autonomic portion of the peripheral nervous system there are also motor and sensory nerves. The motor nerves within the autonomic system are further broken down into sympathetic and parasympathetic. The sympathetic nerves are responsible for stimulation, mobilization, and response to stress. The parasympathetic nerves are associated with conservation of energy, restoration of energy stores, and calm activities. Many organs are innervated by both types of nerves.

The Autonomic Nervous System



The cells that make up the nervous system have the same needs as other cells and are of two types. There are both neurons and glial cells. The glial cells provide a soft structural support for the functional components of the nervous system. They also create a soft matrix for the rest of the nervous system to lie in.

THE NEURONS

The neurons are the actual "functional" cells of the nervous system as these are the nerves that actually receive and transmit impulses. They have long cytoplasmic extensions called dendrites and axons. The dendrites extend from the cell body and are highly branched. They are the part of the neuron that receives the impulse. The axons are long single extensions from the cell body and serve to transmit the message to the next neuron or the effect organ. Some of these may have collateral branches. Neurons may be unipolar, bipolar, or multipolar.

Many neurons grouped together make up a nerve. They are several bundles of axons joined together in fascicles. Within the central nervous system they are not called nerves but are called pathways or tracts. The cell bodies attached to all these bundled neurons group together to form ganglia.

REFLEX ACTIONS

The reflex action is the simplest neural response in the body. It is a predictable, autonomic response to a specific stimulus. Reflex action regulates most internal mechanisms such as body temperature and other homeostatic functions. Reflex actions also may be involved in some external stimuli such as with the knee-jerk or immediate reaction to pain.

There are also reflexes that can be learned such as driving, walking, and typing. The reflex action involves reception, transmission, integration, and response. In some instances, a sensory nerve may actually synapse with a motor nerve circumventing the central nervous system altogether. This is called a monosynaptic reflex. Polysynaptic reflexes can be overridden through inhibition or facilitation.

NERVE EXCITATION

There are things that can cause the nerves to be more excitable and more likely to transmit an impulse. Any substance that increases sodium permeability of the cell membrane will cause excitation of neurons. If there is decreased permeability, there will be a depression of neural response. Low calcium levels will cause an increased flow of sodium into the cell, causing a lower resting potential. This may cause spontaneous firing of the neuron. An example of this manifestation is called low calcium tetany, which may be observed as uncontrollable muscle tremor. Other agents that may cause increased or decreased excitability of neurons are narcotics, anesthetics, some pesticides, and the chlorinated hydrocarbons.

NEUROTRANSMITTERS

Most synaptic junctions are too far apart for the neural impulse to jump the gap. These transmissions must be aided by a chemical transmitter that allows the impulse to travel from one side of the synapse to the other. Once these transmitter substances are released by the cells, they must be reabsorbed or deactivated by enzymes.

There are about 30 known transmitter substances in the body, and many neurons contain more than one. This course will be limited to but a few, these being the ones important to the toxicology of hazardous materials. Many postsynaptic neurons have receptor sites for more than one transmitter substance.

ACETYLCHOLINE

One transmitter that is very important in the study of hazardous materials toxicology is acetylcholine. Acetylcholine is used by motor neurons that innervate skeletal muscle, some neurons in the autonomic system, and by some brain cells. These neurons are called cholinergic neurons. The acetylcholine is released by the presynaptic neurons and increases sodium permeability of skeletal muscle fiber. It has an inhibitory effect on the heart and certain other muscles within the body. Once acetylcholine is released, it must be broken down by an enzyme known as cholinesterase. It cannot be reabsorbed by the neuron.

Norepinephrine is released by sympathetic neurons and by some brain cells and spinal cord neurons. Norepinephrine, along with epinephrine and dopamine, are released by a group of neurons known as the adrenergic neurons. These transmitters are reabsorbed to be used again after they have performed the desired function.

OTHER TRANSMITTERS

Other transmitter substances include endorphines and gamma amine butyric acid. Gamma amine butyric acid is an inhibitory transmitter in the brain and spinal cord. It can be thought of as a substance that keeps everyone from seizing all the time by inhibiting certain impulses in the brain and spinal cord. This will be relevant later in the discussion of certain hazardous materials.

THE CELL

Cells are the living units of the body. Many cells together make up organs, which make up systems, which make up the entire organism. The cells are connected by intercellular supporting and connecting structures. Each of the approximately 75 trillion cells in the body is designed to perform a specific function. It is this function that determines a cell's construction. For instance, the sperm cell has a rounded body with a whip-like tail to propel it along, nerve cells have a special shape, epithelial cells have a specific shape, and so forth.

Regardless of the function of the cell, or the way it is structured, all cells have certain things in common. All cells require nutrition and oxygen. This allows for the production of energy to carry out the specialized function of the cell. This oxygen-to-energy transformation is similar in all cells and will be discussed in more detail later. Metabolism always produces waste products, and cellular metabolism is no different. All cells also must have the ability to excrete and eliminate waste products. Additionally, most cells must have the ability to reproduce.

CELLULAR FLUIDS

The cells contain fluid and are bathed in a fluid called the extracellular fluid. In fact, 56 percent of the human body is fluid. This fluid can be classified as intracellular fluid (fluid within the cell), or extracellular fluid (fluid found outside of the cells). The extracellular fluid contains the nutrients and ions necessary for the cells to live. This fluid is in constant motion, so materials in the extracellular fluid tend to move about rather rapidly. There is continual movement caused by the body's circulation of blood and lymph. Fluid is constantly diffusing from the blood and the tissue fluids. This results in a relatively similar environment for all cells.

TYPES OF CELLULAR FLUIDS

The extracellular fluid can be divided into the intravascular fluid and the extravascular fluid. As the names imply, one component is contained within the blood vessels and the other is outside the vascular space. As previously mentioned, this fluid is in constant motion between the two compartments and is regulated to keep the pressure within the vessels at a tolerable level. An increase within the vascular space will result in a rise in blood pressure, but the extravascular compartment is extremely tolerant of differences in volume. The main components of the extracellular fluid are sodium, chloride, bicarbonate, nutrients such as oxygen, glucose, fatty acids, and amino acids, and waste products. These extracellular ingredients are much different than those found in the intracellular environment.

The intracellular fluid consists mainly of potassium, magnesium, and phosphate. The concentration gradients between the two fluids are maintained by special mechanisms that will be discussed later. Noticeably missing is the calcium ion, and this point also will be discussed later. The concentration of ions, nutrients, and waste products, as well as the role of calcium, are part of a process known as homeostasis. Earlier we stated that this is the physiological equilibrium produced by a balance of functions and chemical composition in an organism.

CELLULAR METABOLISM

As was mentioned earlier, each cell within the body is conducting its own individual metabolism. This is not to suggest that cells exist independently of one another; in fact they are all very dependent on one another for life to continue. The regulation that occurs to keep all the cells working together is called homeostasis. Essentially all organs and tissues in the body are involved in homeostasis. Anything that upsets homeostasis is called a stress. It is automatic for the body to respond to stress and try to maintain homeostasis. This is done through a variety of mechanisms.

The "key players" in homeostasis can be thought of as the movement of fluids, nutrition, removal of wastes, and regulation of body function.

FLUID MOVEMENT

Fluid movement within the body occurs in two main stages. First there is the movement of blood around the circulatory system, and second, the movement of fluid between the capillaries and cells. There is a continual exchange taking place between the plasma and the interstitial spaces. The capillaries are quite porous and this porosity allows fluids to leave the vascular space where they then move freely to the cells. Most cells within the body are within 25 to 50 microns of a capillary. This fluid movement allows for the delivery of oxygen and nutrients and the removal of metabolic wastes.

NUTRIENTS

Nutrients are acquired from two locations, the lungs (oxygen) and the gastrointestinal tract. The gastrointestinal tract is where the bloodstream picks up such key nutrients as carbohydrates, fatty acids and amino acids. These nutrients are not always usable by the cells, so their biotransformation occurs in the liver. Another important component of nutrition is the musculoskeletal system, because without the ability to move about, it would be hard to get anything to eat. Once these nutrients are metabolized by the individual cell, the waste products must be removed. Carbon dioxide is transported to the lungs and exhaled and urea and other waste products are excreted by the kidneys.

The main player in the game of homeostasis is the regulation of body functions. Body functions are controlled by the nervous system with assistance from the hormonal system. Together these systems cooperate to achieve a harmonious balance of bodily functions.

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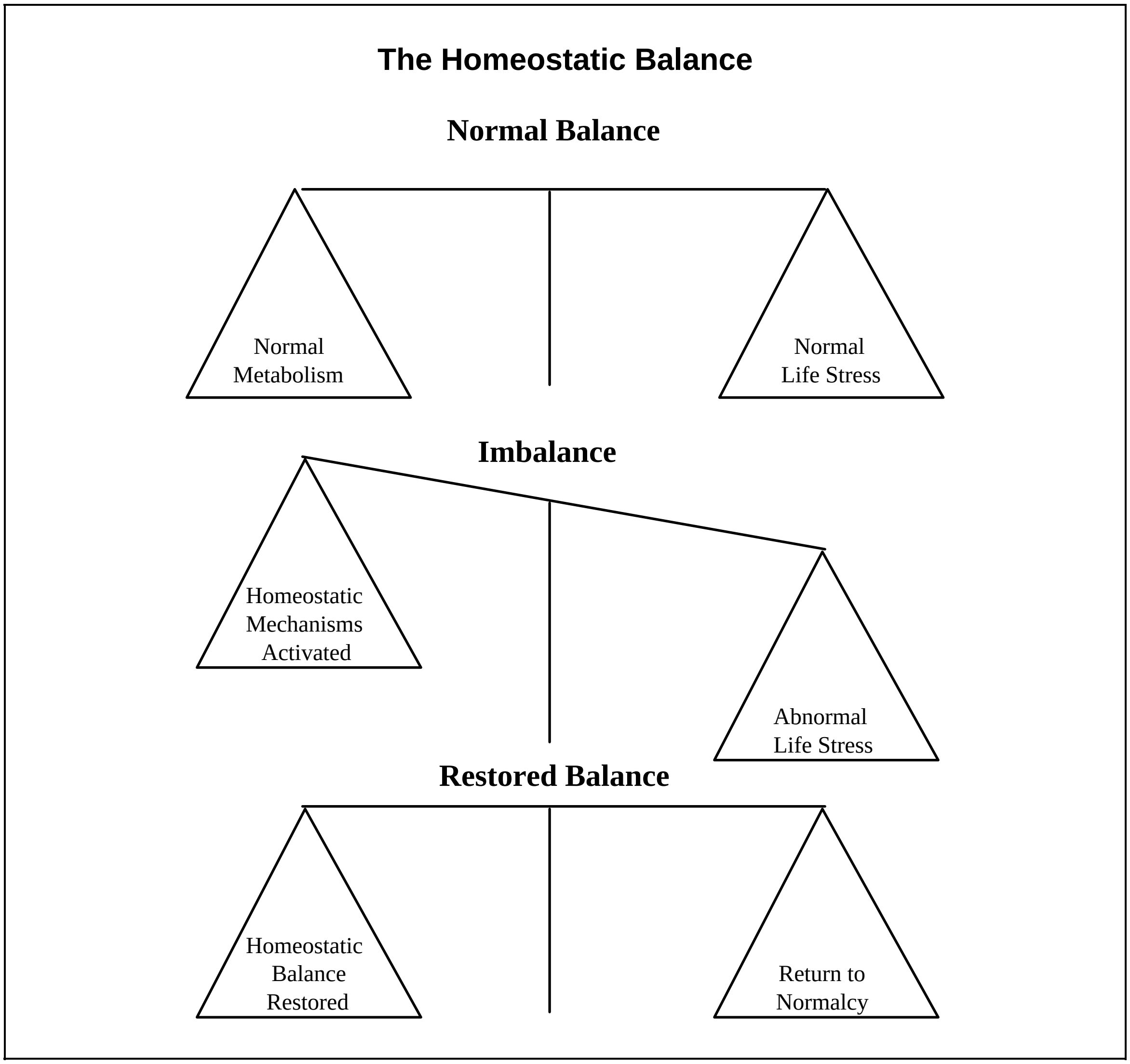


The Homeostatic Balance

THE NERVOUS SYSTEM

The nervous system consists of three main parts. These are the sensory portion, the integration portion, or the central nervous system, and the motor portion. These parts can be further subdivided by function, and these subdivisions will be examined later. The sensory receptors are what keep the body aware of surroundings. The sensory receptors send messages to the central nervous system where decisions on appropriate response are made. The motor portion of the nervous system then innervates the appropriate cells for the body to respond to the messages received.

THE ENDOCRINE SYSTEM

The hormonal system consists of eight major endocrine glands that secrete chemical substances called hormones. These hormones are transported throughout the extracellular fluid to all parts of the body to help regulate function. One example of a hormone is insulin. It facilitates the diffusion of glucose into the cell and the use of the glucose once it enters the cell. The hormonal system complements the nervous system by regulating some of the slower metabolic functions, whereas the nervous system controls the more immediate functions like motor and autonomic activity. Specific endocrine glands and hormones will be discussed later in the course.

THE LIVING CELL

All human beings began life as a single cell: a fertilized egg. Through cellular reproduction, we all became what we are today: 70 to 100 trillion cells, each carrying on its own individual metabolism. The cell is the smallest part of the body capable of independent life. There is no known medium that will keep individual components of the cell alive other than the environment of the cell itself. The internal environment of the cell consists of the nucleus, the cytoplasm, electrolytes, proteins (both structural and enzymes), lipids, and carbohydrates.

INSIDE THE CELL

The cytoplasm is a general term for the fluid inside the cell membrane, excluding the fluid within the nucleus. It consists of the cellular organelles, water, and suspended particles. It is this fluid medium that allows for transport within the cell and for the necessary chemical reactions needed to keep the cell alive. The predominant electrolytes are potassium, magnesium, phosphorus, sulfate, and the bicarbonate ion.

Also found in small amounts are the sodium and chloride ions. The proteins make up about 10 to 20 percent of the total cell mass. They consist of structural proteins that provide a framework for the cell, and enzymes that are critical for chemical reactions that must take place. The structural proteins tend to be fibrillar and generally consist of long thread-like fibers. The enzymes are single molecules or a few molecules grouped together in a globular configuration. These proteins may be dissolved in the fluids of the cell or may be attached to surfaces within the cell. Their principal function is to catalyze chemical reactions.

DNA AND RNA

The nucleoproteins, DNA and RNA, are responsible for hereditary characteristics. The lipids are fat-soluble and consist of the triglycerides, phospholipids, and cholesterol. These are prevalent in the membranes and combine with structural proteins to create selective barriers to fluid movement. The carbohydrates have very little structural function, but are important to the nutrition of the cell. Carbohydrates are generally broken down before they are used by the cell and are stored as glucose outside the cell, and as glycogen within the cell.

CELLULAR STRUCTURE

Membranes line the cell itself and the structures contained within it. These membranes are not identical but tend to be similar in structure. The cell membrane, or the membrane that contains the entire cell and its contents, consists mostly of lipids with some proteins. The central layer of the membrane is made from a bilipid layer while the outside of this lipid layer is covered by a thin layer of proteins on each side of the membrane.

Also present is a thin film of mucopolysaccharide on the outside of the outer protein layer. This causes water to adhere easily to the membrane on its outer surfaces. But the bilipid layer in the center causes the membrane to be practically impervious to lipid-insoluble substances, such as water. The presence of mucopolysaccharide on one side of the membrane causes the membrane to be somewhat polar, meaning the chemical reactions taking place inside the cell are quite different from the reactions taking place outside the cell.

Although the exact structure of the membrane is not truly understood at this time, there are thought to be small pores in the lipid layer of the membrane about eight angstroms in diameter. What is known is that molecules smaller than eight angstroms are able to diffuse freely through the membrane.

One line of thought is that there are no protein layers at all. Instead, it is suggested that the proteins are imbedded within the lipid layer and may in fact be responsible for the formation of the pores just mentioned. This cell membrane just described is sometimes referred to as the "unit membrane." This unit membrane is found in all areas of the cell where membranes are present, though in slightly different form.

Other membranes within the cell include the nuclear membrane, the endoplasmic reticulum, and the golgi complex.

THE NUCLEAR MEMBRANE

The nuclear membrane, as the name implies, is the membrane that encloses the nucleus of the cell. In fact, the nuclear membrane consists of two unit membranes with a space between them. The structural difference between the nuclear membrane and the cell membrane is the absence of the mucopolysaccharide layer on the outer surface of the nuclear membrane. Also, the pores of the nuclear membrane are much larger than the pores in the cell membrane. They are thought to be several hundred angstroms in diameter, resulting in almost all dissolved substances within the cell moving freely across this membrane.

THE ENDOPLASMIC RETICULUM

The endoplasmic reticulum is a tunnel-like network of membranous material that runs throughout the cell. It is continuous with the membrane around the nucleus and creates a series of passageways and vessels that allow for transport within the cell. Some of this membrane material is smooth and some of it is granulated with small particles called ribosomes. The smooth, or nongranular, reticulum produces steroids in some cells, stores calcium in muscle cells, and is a component of fat metabolism in liver cells. The smooth reticulum is functional in the detoxification of some materials that enter the body.

The rough reticulum is given its rough appearance by the presence of ribosomes. The ribosomes are actually organelles of the cell and may be attached to the outer walls of the rough reticulum or they may be found floating freely in the cytoplasm. These ribosomes are elements of protein synthesis. Some cells, which actually export proteins, have extensive networks of rough reticula. An individual cell actually can convert smooth reticula to rough reticula depending on the needs of the cell.

THE GOLGI COMPLEX

The golgi complex is a series of plate-like membranes that are actually a specialized portion of the smooth endoplasmic reticulum. The main function of the golgi complex is secretion and these apparatus are more extensive in cells that secrete as their main function. Even in cells that are not secretory cells, the golgi apparatus is believed to be responsible for elimination of intracellular digestive enzymes. The golgi complex in some cells secrete mucous and the ground substance for bones and cartilage. Proteins synthesized in the rough endoplasmic reticulum are secreted through the golgi complex as are the lipids formed in the smooth reticulum. Lysosomes, which can be thought of as the digestive "organs" of the cells, are produced within the golgi complex.

THE ORGANELLES

Just as cells are living, much the same as humans live, the cells contain organelles, or "little organs" that are analogous to the organs within the human organism. All of these organelles, as well as the other particulates within the cell, exhibit at least some degree of polarity. This polarity causes an attraction to water and also causes the suspended particulates to repel one another, keeping them suspended in the cytoplasm.

One very important organelle found within the cell is the mitochondria. The function of the mitochondria is to extract energy from nutrients and oxygen and to provide this energy to other parts of the cell where it is needed for cellular metabolism. The actual number of mitochondria will differ from cell to cell, depending on the energy needs of the individual cell. There will usually be between a few hundred and several thousand in each cell.

THE LYSOSOMES

The lysosomes are the "digestive organs" of the cell. They allow the cell to digest and remove any unwanted substances, especially damaged structures and bacteria. Digestive enzymes are manufactured in the rough endoplasmic reticulum and then are transported to the golgi complex. Once there, the enzyme is wrapped in a small amount of membrane from the golgi apparatus and released into the cytoplasm. This is a lysosome. This lysosome then can attach itself to any unwanted material, release its enzymes, and digest the material. The lysosome also can digest other structures within the cell and release the byproducts as fuels to be used by the remainder of the cell, and can also cause the self-destruction of damaged or unhealthy cells.

THE NUCLEUS

The nucleus is usually found in the "center" of the cell. Usually, it is relatively large and spherical and serves as the control center or "brain" of the cell. As mentioned earlier, the nucleus is surrounded by a double layer of unit membrane. The fluid within the nucleus is called the nucleoplasm and is more viscous than the cytoplasm. The nucleus contains the DNA of the cell and this is where chromosomes will be produced when the cell is getting ready to reproduce. As you probably already know, the chromosomes are composed of several hundred genes arranged in a specific linear order. The genes, in turn, are made up of DNA.

Since each cell has a specific function, it is only reasonable to expect that energy is needed to carry out those functions. The major cellular functions are membrane transport, protein synthesis, and muscle contraction. Essentially what happens is that the cell takes in nutrients and oxygen, and uses the oxygen to "burn" the nutrients. This takes place in the mitochondria. The resultant energy then is transported to the area of the cell where it is needed for cellular function.

MAIN TYPES OF NUTRIENTS

The three main types of nutrients are carbohydrates, fats, and proteins. Of course, prior to being used by the cells, these nutrients are converted to glucose, fatty acids, and amino acids respectively. Inside the cell, the energy released from the reaction of nutrients and oxygen is converted into adenosine triphosphate (ATP) which then is used as a sort of "energy currency." ATP is a molecule that contains three phosphate radicals that are bonded by a high energy phosphate bond. This bond, when broken in the cell, is capable of releasing tremendous amounts of energy. Once this phosphate bond is broken and the energy is released, the remaining compound is call adenosine diphosphate (ADP). This ADP then is transported back to the mitochondria and, using the energy from nutrients and oxygen, is chemically combined with a phosphate radical to form new ATP, starting the cycle over again. The high energy phosphate bond is very labile, which means it is easily broken on demand to provide energy wherever needed.

A small amount of ATP is produced outside the mitochondria when glucose first enters the cell. Glucose is converted into pyruvic acid by a process called glycolysis. This reaction requires no oxygen and results in the formation of two ATP molecules. Because no oxygen is required for this reaction, it is referred to as anaerobic metabolism. In contrast, the ATP formed in the mitochondria requires oxygen and is referred to as oxidative energy metabolism. Each cycle of oxidative energy metabolism results in the formation of 36 ATP molecules.

ENERGY PRODUCTION

Let's summarize what occurs to produce energy in the cell. Glucose, fatty acids, and amino acids enter the cell. Glucose is converted into pyruvic acid by glycolysis, resulting in the formation of two ATP molecules. The fatty acids and the amino acids are converted into a compound known as acetoacetic acid. Pyruvic acid and acetoacetic acid combine chemically to form a compound called acetyl co-A. Acetyl co-A and oxygen are transported to the mitochondria.

Once in the mitochondria, the acetyl co-A and oxygen are converted into hydrogen atoms and carbon dioxide. The carbon dioxide diffuses out of the cell and is carried back to the lungs for exhalation. The hydrogen atoms combine with oxidative enzymes releasing tremendous amounts of energy. This energy is in turn used to form ATP from ADP. The ATP is then released back into the cell for use wherever needed. Once the ATP is used as an energy source, the remaining ADP is transported back to the cell to start the cycle over again.

TRANSPORT THROUGH CELL MEMBRANES

As discussed earlier, the fluid inside the cell is very different from the fluid outside the cell. These differences are allowed due to the semipermeability of the unit membranes that separate the different areas of the cell. As environmental conditions or the needs of the cell change, a membrane may block the passage of one material at one time, and actively promote its passage at another time. All of this results in the cell controlling its chemical makeup by regulating the movement of chemicals through the membranes of the cell.

The movement of materials across cellular membranes may be active or passive. Passive forms of transport include diffusion, osmosis, and filtration, while the active means of transport include active transport, phagocytosis, and pinocytosis. The active forms of transport require the expenditure of energy by the cell and this energy comes from the processes that were just previously discussed.

All molecules, ions, and particles in the body are in constant motion, with each moving its own separate way. With all of this random movement, molecules continually hit one another and bounce off in different directions. The molecules will seek to distribute themselves evenly across any given medium. This process is known as diffusion. Because this movement is random, the laws of probability favor movement from areas of higher concentration to areas of lower concentration.

Another key factor in movement of molecules is the velocity the molecules obtain. This is a function of molecular size and temperature. Quite naturally, larger molecules will move more slowly than smaller ones, and the higher the temperature, the greater the rate of molecular and particulate movement.

THE ANALOGY OF VAPOR

To graphically explain what occurs during diffusion, consider the release of a vapor into a room. Initially, the vapor will be very concentrated at the point of release. However, as time goes on, the vapor will spread throughout the room by random molecular motion. At some point the concentration of the vapor will be the same at every point in the room. The amount of time it takes for this equalization to occur depends on the factors that were just mentioned, i.e., concentration gradient, room size, molecular size, and temperature.

DIFFUSION

The process of diffusion is important to cellular life and therefore to the life of the organism itself. For instance, oxygen from the atmosphere actually diffuses from the alveoli to the bloodstream due to the difference in concentration of oxygen in the air breathed compared to the concentration of dissolved oxygen in the blood that is returning from the body. Since this blood has been out to the cells of the body giving up its oxygen, once again due to concentration gradients, it returns to the lungs deficient in oxygen.

We saw earlier that the cell membrane is selectively permeable. In other words, the membrane around a cell will permit some materials to move easily across it while it will be more resistant to the movement of other materials. One common example is the movement of oxygen as compared to the movement of glucose.

FACILITATED DIFFUSION

Oxygen tends to move rather freely across the cell membrane, while glucose, which is a relatively large, polar molecule, does not move as easily across the lipid matrix of the cell membrane. Since most cells in the body need an almost continuous supply of glucose, there must be a mechanism for the movement of glucose across the cell membrane. This mechanism is called facilitated diffusion. In facilitated diffusion, the glucose combines with a protein that allows it to be dissolved in the lipid matrix and therefore diffuse across the cell membrane. Once the glucose diffuses to the inside of the cell membrane, the protein is released to return to the outside of the cell membrane where more glucose is picked up and transported into the cell. This is still a form of diffusion since the movement of the glucose is dependant on a concentration gradient; there must be a higher concentration of glucose outside the cell for glucose to diffuse to the inside of the cell.

This is an overly simplified description of what really occurs, but it should be sufficient for our study. Also, there are other materials transported through this mechanism such as amino acids across the cell membrane.

OSMOSIS

Osmosis is another type of transport that is important to cellular life; it deals with the movement of water across a selectively permeable membrane. Osmosis is based on the principle that water can diffuse freely across the membrane, but many of the solute molecules are unable to do so. If one side of the membrane has a higher concentration of solute molecules, water will move across the membrane in an attempt to reach equilibrium with the solute molecules. If both sides of the membrane have the same concentration of solute molecules, the solutions are said to be isotonic. If one side has a higher concentration of solute, that side is said to be hypertonic to the other and the result will be the movement of water to the hypertonic side. The side with the lesser concentration would be called hypotonic and this side would be the side with a net movement of water away from it to the hypertonic side.

This can be applied to the cell. If a cell is in an environment that has the same solute concentration as the inside of the cell, there will be no net movement of fluid. This is because even though the water will be crossing the membrane, the same amount will be leaving the cell as is entering it. If a cell is placed in a hypotonic environment, water will be pulled into the cell and the cell will swell. If the concentration gradient is great enough, the cell can actually burst.

FILTRATION

Filtration is another type of movement across membranes; it is the result of fluid being forced across the membrane due to hydrostatic pressure. An example of this type of transport is in the movement of plasma out of the bloodstream due to blood pressure. This is what results in the formation of tissue fluid. Filtration is also a key player in the formation of urine in the kidneys. There, plasma is forced out of certain capillaries and into Bowman's capsules. This is the first stage of urine production.

ACTIVE TRANSPORT

Active transport is a form of active movement across a membrane that prevents the principles we have previously discussed from wreaking havoc on certain chemical balances that must be present for life to exist. For instance, the level of potassium inside the cell is much greater than the concentration outside the cell whereas the amount of sodium outside the cell is much greater than the amount on the inside. If diffusion had its way, these differences would eventually be eliminated and the cell would no longer function as designed.

To overcome the natural forces of diffusion, the cell must expend energy to actively "pump" these ions in a one-way direction against the concentration gradient. Currently it is believed that large proteins line pores within the wall of the cellular membrane. These pores undergo a conformational change once the ion enters the pore that results in the ion actually being squeezed through the pore to the inside of the cell. This "sodium pump" that keeps the potassium and sodium levels correct inside and outside the cell are the most well known of the active transport mechanisms, but are not the only ones that exist. For this course, we will restrict our discussion to the "sodium pump."

ENDOCYTOSIS

Endocytosis is another form of active transport. There are two types of endocytosis, phagocytosis and pinocytosis. Pinocytosis occurs when substances too large to penetrate the cell wall are taken into the cell. What essentially occurs in endocytosis is that the material to be ingested is wrapped in folds of the cell membrane which then forms a vesicle that is pinched off inside the cell.

In phagocytosis, the vesicle is attached to by a lysosome which pours its powerful enzymes into the vesicle, resulting in digestion of the foreign material. Phagocytosis is used exclusively with solid particles. When the ingested material is a liquid, pinocytosis occurs. The liquid is surrounded by a vesicle, but this vesicle transfers its contents into the cytoplasm and the vesicle itself seems to dissolve within the cytoplasm. In simplistic terms, phagocytosis is the mechanism by which a cell eats and pinocytosis is the mechanism by which a cell drinks.

SUMMARY

The thing to keep in mind about the cell membrane is that it is a lipid layer that has a tendency to repel water. There are some materials that diffuse well in water, but do not diffuse through this lipid layer very well. Other materials, however, diffuse well in water and also diffuse well in lipids. Examples are oxygen, carbon, dioxide, alcohols, and fatty acids. Materials that will not diffuse through the lipid layer must depend on active transport mechanisms to enter the cell.

APPENDIX C

PESTICIDES

PREVALENCE OF PESTICIDES

Just about any home has pesticides in the form of bug repellants or sprays. Homemakers who do landscaping are likely to have many more. Some of these are highly toxic.

There are approximately 35,000 pesticide products used in the U.S. They come from about 1,000 base chemicals. They fall into five major groups of pesticides in common use.

Major Pesticide Groups

- Insecticides: insect or bug killers
- Herbicides: weed and vegetation killers
- Rodenticides: mouse and rat killers
- Fungicides: fungus killers
- Acaricides: lice, flea, and parasite killers

Pesticides used in the U.S. must bear a label containing at least six key items. This information is very important for the emergency responder.

1. A signal word such as caution, warning, or danger. These words range from the least harmful (caution) to the most harmful (danger).

2. Antidotal or treatment information.

3. A statement of the product's chemical and physical hazard.

4. A list of product ingredients.

5. The Environmental Protection Agency (EPA) number.

6. The product name.

POISONING CAN OCCUR IN MANY WAYS

Pesticide poisoning can occur through direct contact with the product, contact with the vapors, with runoff, or with smoke from a fire involving the product. One complicating factor associated with pesticide poisonings is the fact that they may be confused with other somewhat common fireground injuries such as heart attacks, smoke inhalation, or heat-related emergencies. Many pesticides can be fatal even in very small doses.

The routes of entry for pesticides are the same as for other hazardous materials.

We now will look at the major categories of pesticides and methods of treatment.

Principles of Pesticide Treatment

1. Remove the patient from the source of contamination.
2. Protect oneself.
3. Decontaminate.
4. Manage the patient's airways.
5. Monitor the patient closely.
6. Treat symptoms as they develop.

ORGANOPHOSPHATE INSECTICIDES

As the name implies, these products are used to exterminate insects and are quite common in most areas of the country. In fact, many people have these products in the home, although they may be in small quantities and in "weak" concentrations.

Some of the highly toxic organophosphates include such products as tetraethyl pyrophosphate (TEPP), disulfoton, fensulfothion, mevinphos (Phosdrin, Duraphos), dioxathion, methyl parathion, ethyl parathion, coumaphos, chlormephos, dicrotophos, carbophenothion, endothion, and many others.

Some less toxic compounds, but still quite deadly are leptophos, dichlorvos, ethoprop, triazophos, ethion (Ethanox), chlorpyrifos (Dursban), sulprofos, crotoxyphos, malathion, and methyl trithion.

The toxic mechanism of the organophosphates is the phosphorylation of the cholinesterase enzyme at nerve endings that use acetylcholine as a neurotransmitter. Once the effects of cholinesterase have been inhibited, the acetylcholine present at the neural junction will continue to transmit messages from one neuron to another. This is occurring at the cholinergic neuroeffector junctions (muscarinic sites), at the skeletal muscle nerve-muscle junctions (nicotinic sites), at the autonomic ganglia (nicotinic), and in the brain. This results in a number of problems, including muscle contraction, hypersecretion, muscle twitching and paralysis, behavioral disruptions, incoordination, and depressed motor function.

The presentation of organophosphate poisoning usually will occur within four hours of an acute exposure and quite often will occur during the exposure period.

Presentation of Organophosphate Poisoning

- Headache, nausea, vomiting
- Muscle twitching and incoordination
- Abdominal cramps and diarrhea
- Hypersecretion (sludge)
- Blurred or darkened vision
- Wheezing, coughing, frank pulmonary edema
- Brachycardia often preceded by tachycardia
- Toxic psychosis
- Unconsciousness
- Convulsions
- Respiratory depression
- Incontinence
- Chronic effects such as anorexia, weakness, and malaise

In cases of a strong clinical indication of organophosphate poisoning, one should not delay treatment while waiting on confirmation of mechanism. It is imperative to decontaminate the patient and protect oneself from contamination. Some of the organophosphates are very toxic even in small doses.

TREATMENT

It is important to maintain open airways and to assure proper respiration. Suctioning may be indicated along with high-flow oxygen therapy. Assisted respirations may be needed. Nasotracheal intubation should be given early consideration especially in the presence of remarkable pulmonary secretions.

Atropine

Atropine should be administered in the following dose: 1 to 2 mg. every 15 minutes until atropinization is achieved. The benchmark of effective atropinization is the drying of mucous beds. One should not depend on lung sounds to gauge the effects of the atropine as there may be residual fluid in the lungs.

Some patients may require large doses of atropine. Furthermore, the administration of atropine does nothing for the nicotinic effects of the organophosphates. In severe cases, it may be necessary to increase the dose and shorten the time between doses. There is no arbitrary end point in atropine therapy when treating organophosphates.

2-PAM

There is an additional medication that may be used for organophosphate poisonings. It is called pralidoxime or 2-PAM. It usually is not given as field therapy. It is used to reactivate the cholinesterase and should be given only after blood analysis.

Diazepam

Further complications such as seizure activity should be treated as needed. This is done with diazepam. Immediate life-threatening problems should be the target of field therapies. Even though there is fluid buildup in the lungs, the use of traditional pulmonary edema therapies is questionable. In any case, responders always must follow local protocol.

Ingestion Injuries

These should be treated according to local protocol; advice from a poison control center needs to be factored in. Treatment should be geared toward emptying of the intestines and removing the toxin. Responders need to remember that any emesis from these patients could present a significant hazard to rescue personnel.

All of the above treatments should be administered based on clinical indication and should never be instituted prophylactically.

CARBAMATE INSECTICIDES

The carbamates are also used to exterminate bugs and are very similar to the organophosphates in a lot of ways. Some of the more toxic carbamates are aldicarb (Temik), methiocarb, carbofuran, aminocarb, clethocarb, and bendiocarb. Less toxic, but still dangerous carbamates include dioxicarb, promecarb, bufencarb, trimethacarb, and carbaryl (Sevin). The carbamates, as well as the organophosphates, are readily absorbed by all routes.

The mechanism of harm with the carbamates is very similar to the organophosphates in that there is an inhibition of cholinesterase. However, this inhibition is reversible and does not require the use of pralidoxime.

The clinical picture is identical to the organophosphates and the field treatments are the same.

ORGANOCHLORINE INSECTICIDES

These, too, are bug killers and go by such names as endrin, aldrin, endosulfan, dieldrin, toxaphene, lindane (Kwell), DDT, and chlordane. They are readily absorbed by all routes of exposure and absorption may be enhanced by the presence of fat solvents. The organochlorines are readily fat-stored and may be reabsorbed by the body many times prior to excretion or elimination.

The organochlorines interfere with ion flux across nerve cell membranes. This interferes with axonic transmission of neural impulses. This increases neuron irritability with an end result being seizure activity of varying degrees. There is also increased cardiac irritability. Liver damage is also a possibility.

Treatment of organochlorine poisonings is based on symptoms.

Presentation of Organochlorine Poisoning

- Headache, dizziness, nausea, vomiting
- Sensory disturbances
- Confusion and incoordination
- Seizures, coma, and death (Seizures may be delayed by as much as 24 to 48 hours and may recur over several days.)
- Chronic effects:
  - weight loss
  - tremors
  - weakness
  - elevated liver functions
  - slurred speech
  - chest and joint pains

For seizures, treatment of choice is diazepam. Dose is according to the clinical picture. As always, responders need to be alert for respiratory depression. In severe cases, a paralytic may be indicated. But, as has been said over and over again, responders need to follow local protocols in deciding on treatment.

Respiratory insufficiency should be treated with aggressive airway maintenance, oxygenation, and ventilation.

For ingestion injuries, aggressive airway protection and gastric emptying can be used but will depend on local protocol. Also, one can consider the use of activated charcoal, always according to local practice.

One must avoid the use of adrenergics and atropine, since the myocardium is already irritated.

CHLOROPHENOXY HERBICIDES

The chlorophenoxy compounds are common herbicides with wide application as a broad leaf weed defoliant. Common names are 2.4 D, Super D Weedone, Weedone, 2,4,5T, Line rider, Fence rider, Dedweed, and mixtures such as Agent Orange.

The chlorophenoxy compounds are moderately irritating by all routes of exposure. They are not significantly fat-soluble and are excreted in the urine. They can cause demyelination of the spinal cord and may cause local injury to the liver and kidneys, as well as the CNS. Metabolic acidosis may result, along with damage to striated muscle. The chlorophenoxies are weak uncouplers of oxidative phosphorylation, which as you will recall, interferes with cellular energy production. Increased cellular metabolism may result in hyperthermia.

Presentation of Chlorophenoxy Poisonings

- Irritated, reddened skin and mucous beds
- Burning in the nasopharynx and chest
- Nausea, vomiting, diarrhea if ingested
- Headaches, confusion, bizarre behavior
- No significant respiratory depression
- Slight muscle twitching (Seizures are rare.)
- Unconsciousness possible, usually transient to urinary secretion

The chlorophenoxy compounds are rarely fatal even in intentional overdoses. Treatment should be geared towards the symptoms that are present.

As always, responder protection and decontamination should be considered. Intravenous fluids may be administered to speed excretion and help alleviate kidney damage, if local medical control permits.

PHOSPHORYLATION UNCOUPLERS

The phosphorylation uncouplers are widely used in agriculture as an herbicide, nematocide, acaricide, and fungicide. They also are used in the manufacturing of explosives, in film development, and in wood treatment. Common names are dinitrophenol, dinitrocresol, Kiltrol, Veg-i-kill, Wood tox, PCP (sodium pentachlorophenate), Endosan, Hel-fire, Acricid, and Dinosam.

These uncouplers are toxic by all routes, and fatalities have been reported after dermal exposures. They are only moderately irritating to skin and mucous beds. The half-life is 5 to 14 days and these compounds are biotransformed for excretion by the liver. The toxic mechanism is uncoupling of the ADP-ATP conversion within the mitochondria of the cell. The resulting increased oxidative metabolism leads to hyperthermia, dehydration, and tachycardia. The hyperthermia and the direct toxic effect of the compound can cause cerebral edema. This may lead to toxic psychosis.

Presentation of Phosphorylation Uncouplers

- Yellow staining
- Yellow sclera, urine
- Profuse sweating, thirst
- Headaches, confusion
- Warm, flushed skin
- Restlessness and apprehension
- Manic behavior
- Unconsciousness
- Cyanosis and seizures

Treatment for the phosphorylation uncouplers includes rescuer protection and decontamination. Body temperature should be reduced and plenty of oxygen provided. In the absence of pulmonary edema, one should administer intravenous fluids. Responders need to control agitation and involuntary muscular activity with diazepam.

If ingested, one needs to remove it from the stomach following local protocol. Aspirin should be avoided. Some suggest that glucose may be effective in enhancing anaerobic metabolism on which the cell will depend in the absence of an effective ADP-ATP conversion within the mitochondria. In the presence of pulmonary edema, one should use standard treatment modalities. The advice of local medical control is paramount.

DIPYRIDYL COMPOUNDS

Dipyridyl compounds are common defoliants found under names like paraquat, diquat, morfamquat, and in mixtures like Priglone, Preeglone, and Weedone. They are local necrotics and cause damage to all systems they contact.

The damage generally will occur in three phases: local necrosis, systemic damage to the CNS, kidneys, and liver. After about 2 to 14 days, systemic damage may begin in the lungs. The dipryidyls tend to systemically concentrate themselves in the lung where lung cells are destroyed through peroxidation of fats and the formation of free-radical oxygen.

Fluid and WBCs infiltrate the alveoli, resulting in severe hypoxia. There is an eventual loss of pulmonary surfactant and the formation of pulmonary fibrosis.

Presentation of Dipyridyl Compounds

- Arrhythmias
- Coughing
- Headaches, fever and giddiness
- Bloody diarrhea
- Cyanosis
- Air hunger
- Possible seizures
- Burning in the mouth, chest, and abdomen

Treatment of poisonings with dipyridyl compounds is somewhat unique. Except in terminal patients, one should not give supplemental oxygen. In fact, there may be some benefit in having the patient breathe slightly oxygen-deficient air. This will inhibit the formation of free-radical oxygen. Intravenous fluids may be given to treat dehydration, and seizures may be controlled with diazepam. Morphine may be considered for extreme pain. Traditional pulmonary edema therapies are questionable. One should always follow the advice of medical control.

PESTICIDE SOLVENTS

No discussion of pesticide poisonings would be complete without mentioning the solvents used to carry many pesticides. In addition, some pesticides are carried on adjuvants that may be hazardous in their own right. These solvents and adjuvants are used to allow ease of handling and application, to stabilize the active ingredient, and to enhance killing power.

In addition to possibly making the pesticide more toxic, the additives may be proprietary information, so it may be difficult for the rescuer to determine the exact chemical involved. The MSDS should be consulted and the manufacturer queried as to the exact nature of the solvent. Manufacturers are required to divulge trade secrets in emergencies.

There are many types of solvents, including water/hydrocarbon emulsions, toluene, xylene, chlorinated hydrocarbons, and alcohols and alcohol mixtures. Other adjuvants include granular formations such as dusts or clays, talc, silicate carbonate particles, extenders such as milk powder and flour, and emulsifiers.

Also found are penetrants such as certain oils and detergents. These may have a surfactant effect and enhance absorption of the pesticide. The rules against emesis with petroleum products generally are invalid when the petroleum products are used as carriers for pesticides.

OTHER HAZARDOUS MATERIALS

Hydrofluoric Acid

Hydrofluoric acid may be found as hydrogen fluoride gas. When in contact with moisture, this gas will form HF acid. Hydrofluoric acid is used in the glass industry for etching, in the manufacturing of pesticides, refrigerants, fertilizers, and microelectronics. It also may be found at water treatment facilities. HF acid is an extreme necrotic and irritant that may cause a penetrating burn injury. It tends to precipitate calcium in bones and reduces calcium levels in the extracellular fluid. This can lead to inhibition of critical intercellular enzymes.

While there usually will be burns at the point of contact, there may not be in some people. There will be extreme abdominal pain, bloody diarrhea, vomiting, and tachycardia. With eye contact, conjunctivitis and opacification of the cornea may result. There will be severe pain if the bone is involved and with severe cases it will be. Signs of hypovolemia will present along with seizure activity. Respiratory arrest is usually the immediate cause of death.

Treatment would include extreme rescuer protection, oxygenation, and airway maintenance. IV fluids, calcium gluconate gel for burns, and calcium gluconate injection for low-calcium tetany would all be appropriate therapies with the approval of medical control. If the patient is awake and ingestion has occurred, one could administer milk. One should not use morphine for pain. This patient should be monitored for pulmonary edema.

Cyanide

Cyanide poisonings can be fatal very quickly. Cyanide may be found in many locations around the community and has application as a fumigant, metal treatment, cutting of heat-resistant metals, paper manufacturing, photography, blueprinting, and engraving.

Cyanide compounds inactivate the cytochrome oxidase system in the mitochondria and cellular respiration ceases. The patient may present with unconsciousness and death very quickly after the poisoning. Other signs and symptoms may include respiratory paralysis, constriction and numbness of the throat, salivation, stiffness of the jaw, nausea and vomiting, tonic-clonic convulsions, incontinence and paralysis after seizures, fixed, dilated pupils, and bradycardia. The skin remains pink since there is still plenty of oxygen in the bloodstream, and the heart usually will continue to beat after respiratory arrest.

Treatment once again is **absolute** rescuer protection and decontamination of the patient. Definitive care is administration of the cyanide antidote kit. One should begin by having the patient inhale amyl nitrite amps until an IV line is established. This should consist of 300 mg of sodium nitrite, slow IV push over 2 to 4 minutes, while being alert for severe hypotension. Responders should follow this with 12.5 grams of sodium thiosulfate, IV. If symptoms persist, one should repeat at half dose after 30 minutes. It is critical to provide aggressive airway and respiratory maintenance at all times. Diazepam may be needed for seizure activity. Methylene blue should be on hand in case of excessive methemoglobinemia.

Hydrazine

Hydrazine is a reducing agent found around military bases and more and more frequently around water plants. It is used as fuel and is the backup energy source for some aircraft. It is toxic by all routes and inhibits pyridoxine and gamma amine butyric acid. It is extremely corrosive and is, of course, flammable. Persons poisoned with hydrazine will have severe chemical burns at the point of contact, may seize, and may have ocular burns. There is a strong possibility of severe liver and kidney damage and it is a suspected carcinogen.

Treatment is **absolute** rescuer protection and decontamination, best done with a bleach solution. Airway maintenance and seizure control are the mainstays of treatment.

SUMMARY

As has been stated in earlier units, the key fact to remember is that knowledge is power. Good information can make the difference between safe and unsafe response. With many of these hazards, the life of the responder may be threatened as much as the life of the victim. While it is essential to do all one can to save the victim, it is absolutely critical that the responder protect him/herself and not take needless risks.

APPENDIX D

INFORMATION RESOURCES

GENERAL REFERENCE MATERIALS

Hazardous materials units have an almost infinite array of manuals and source books at their disposal. From chemistry, toxicology, meteorology, and metallurgy to nuclear physics, they all are there. There also are industrial and governmental resources.

What would one like to know about? Manufacturing, bulk oil storage, or transportation procedures or regulations? How about nuclear power plant facilities and operations? Or radiation monitoring? All one has to do is contact the appropriate representatives: Factory Mutual Engineering Corporation, the National Fire Protection Association, the American Association of Railroads, a specific railroad line, federal agencies such as FEMA, EPA, DOT, FRA, FAA, and more.

Some source materials may be provided gratis, while others will cost a great deal. Therefore, the size and quality of a hazardous materials unit's library need be limited only by funding and the types of operations in which it might find itself involved, which could be almost anything.

Computers may be used either to store or to retrieve information about chemicals and appropriate personal protective equipment (PPE) via modem and a phone line.

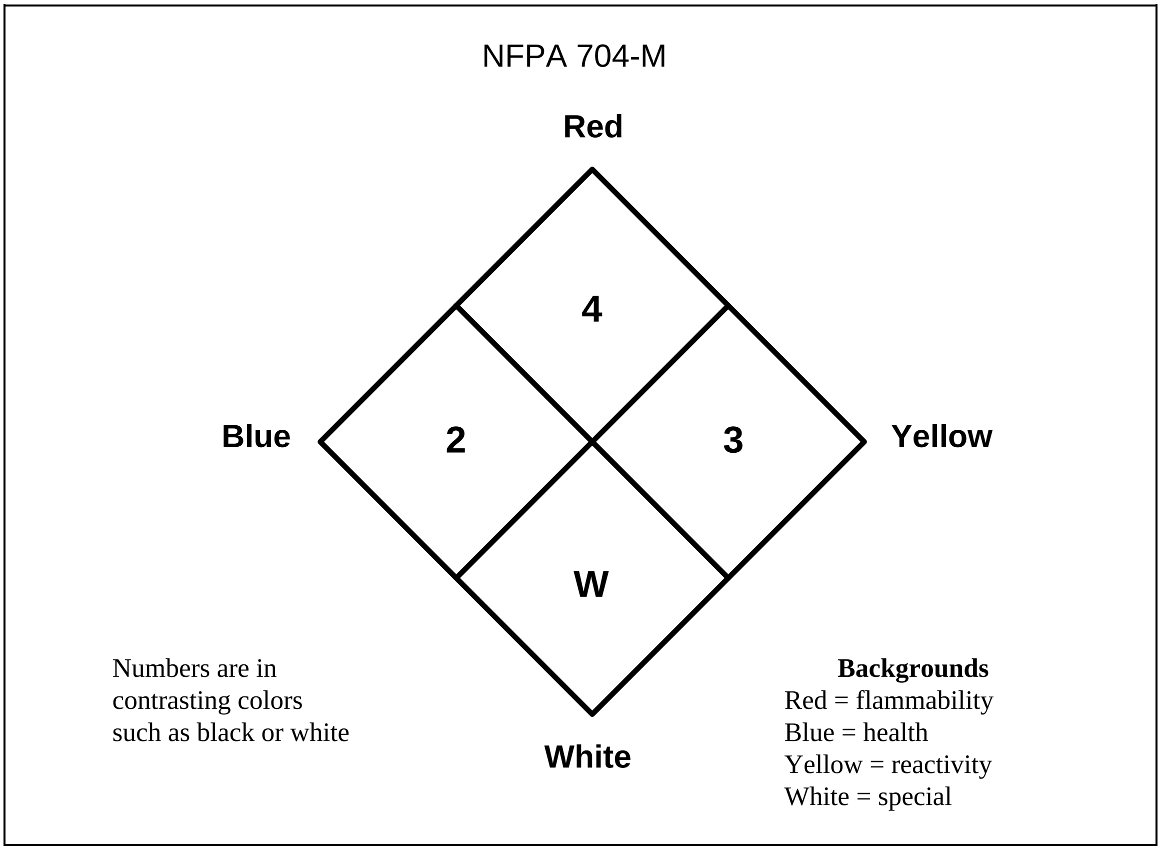
In additional, LEPCs, SERCs, or a fire department's reports on recommended operating procedures for hazard locations, preplanning, or **T**actical **I**nformation for **P**erilous **S**ituations (TIPS) may be kept available in binders or on a computer for access by the hazardous materials unit.

SPECIFIC SOURCES

DOT 49 CFR regulations on placarding and labeling are the first of many visible ways used to help establish the contents of a container. Placards will be found on trucks, trailers, and railcars that carry products deemed to be hazardous as determined by DOT. These placards will consist of a combination of four elements: color, lettering, numbers, and symbols.

Labels found on packages, drums, and other relatively small containers will have similar symbols and markings, but will not use either the two-digit (0.0) North American (NA) hazard category or the four-digit United Nations (UN) numbering systems found on some placards. Since these labels reflect a greater number of hazards than the placards, one will see a greater variety of them. For example, there are no specific placards for etiological (biological) or magnetized materials, but there are labels for these substances.

The National Fire Protection Association (NFPA) over three decades ago designed a method for drawing attention to hazards at fixed installations. It is known as the *Standard System for the Identification of the Fire Hazards of Materials*. It is summarized in the diagram below.



Numbers are in
contrasting colors
such as black or white

Backgrounds
Red = flammability
Blue = health
Yellow = reactivity
White = special

Referred to as the NFPA-704 "diamond," this diagram consists of four joined boxes, each reflecting some area of hazard. Displayed so that the outsides of the corners of the boxes point up, down, to the left, and to the right, each box is of a different color. All but the bottom one will contain a number from 1 to 4.

The box pointing to the left is blue and represents the health hazard. The top box is red and indicates a flammability hazard. The third box, to the right, is yellow and provides the measure of potential reactivity. (The higher the number in the box, the greater the health, flammability, or reactivity risk found in a container, structure, or area so placarded.)

The bottom box has a white background and, though without a number, will have other valuable information. For example, a "W" with a slash through it would tell the observer that the limited use of water is recommended. An "OX" would indicate the presence of an oxidizer.

Use of the NFPA-704 system is not required. It is only an NFPA recommendation that may be voluntarily accepted and used by industry or mandated by the passage of local laws.

HAZARDOUS MATERIALS INFORMATION SYSTEM

Another system in use similar to that of the NFPA is the Hazardous Materials Information System (HMIS). It was developed to respond to requirements of worker "right-to-know" legislation. The important difference between the 704 and HMIS systems is that the latter provides information for employees, intended for daily working environments.

HMIS uses the same colors found in NFPA 704: health (blue), flammability (red), and reactivity (yellow). It also uses the 0 to 4 scale with 4 being the highest level of hazard severity, 0 being the minimal level.

This system arranges the information in a box similar to the one shown here. While it cannot be shown, the top three boxes, from top to bottom, are colored blue, red, and yellow. Each of the colored boxes has a number referring to the level of hazard.

(blue)	Health Hazard
(red)	Flammability Hazard
(yellow)	Reactivity Hazard
(white)	Protective Equipment

As can be seen, there is a fourth, white, box, dealing with the use of protective equipment. It contains a letter which relates to the diagram on the next page.

The diagram contains the letters from A to K indicating standard protective equipment requirements, or an "X" to denote the need for the employee to obtain specific instructions from a supervisor.

HAZARDOUS MATERIALS IDENTIFICATION SYSTEM

Hazard Index

4	Severe Hazard	3	Serious Hazard	2	Moderate Hazard
1	Slight Hazard	0	Minimal Hazard		

Personal Protection Index

A	Safety glasses
B	Safety glasses, gloves
C	Safety glasses, gloves, synthetic apron
D	Faceshield, gloves, synthetic apron
E	Safety glasses, gloves, dust respirator
F	Safety glasses, gloves, synthetic apron, dust respirator
G	Safety glasses, gloves, vapor respirator
H	Splash goggles, gloves, synthetic apron, vapor respirator
I	Safety glasses, gloves, vapor respirator
J	Splash goggles, gloves, synthetic apron, vapor respirator
K	Airline hood or mask, gloves, full protection suit, boots
X	Ask supervisor for specialized handling directions

U.N. SYSTEM

We mentioned earlier the United Nations' four-digit numbering system. It is a method for specifically identifying a container's contents. For example, finding the number 2480 on a placard would tell us that the contents were methyl isocyanate. However, finding 1993 would indicate only that the product could be any one of a great many on the list of materials associated with that number: a combustible or flammable liquid, solvent, creosote, wax, insecticide, ethyl nitrate, and so on.

In the DOT's *Emergency Response Guidebook* (ERG DOT-5800), these four-digit UN identification numbers and the name of a "known" content are cross-referenced. A two-digit Emergency Response Guide number will be found alongside. The guide number reflects, generally, what emergency action should be taken.

As the guide numbers and the recommended actions reflect considerations of what might be only one of several hazards connected with a product, it should not be perceived as the "final" word. It would be far better to letter a product's identity and all of its hazards before proceeding. The *ERG* is, after all, simply a first responder's tool and not something a hazardous materials unit should rely on by itself.

SHAPE OF THE CAR AND STENCILING

The last two of the visible considerations used for identification deal with both railcars and tank trucks. The first is the shape of a car. Because certain types of materials are transported in specific kinds of railcars, shape may be used as a general barometer of what the car may contain.

Lastly, the stenciling on the sides and ends of cars provides useful information. The name of the product within may be printed on the vehicle. Included in the stenciling are the volume capacity of the car, pressure testing information for various components, and the presence of linings or heating pipes or claddings.

DOCUMENTS

Documents of various kinds should be found with materials being transported. Whether shipped by land, sea, or air, a carrier of hazardous materials must provide some listing of product(s) carried. Accessing them amid the chaos of a hazardous materials incident is an altogether different situation.

The document may be called a waybill, a consist, a wheel report, an air bill, or simply a bill of lading. In some cases, the document will give a description of the specific hazards associated with the various materials carried.

On the next page is a Shipping Paper Identification Chart. For the major types of transportation methods, it presents some useful information on the kind of document used, its normal location, and the person responsible for keeping it.

These documents can be very helpful to the responder in determining exactly what product or products are being carried and in what amounts. This information will be helpful in further determining the precise hazard the products present to the responders and to the public.

In the case of trains, the waybill, consist, or bill of lading will help pinpoint the car in which the commodity is being carried. When the train has dozens of cars, this can save some valuable time.

Shipping Paper Identification Chart

Mode of Transportation	Shipping Paper Title	Shipping Paper Location	Responsible Person
Highway*	Bill of Lading	Cab of vehicle	Driver
Railroad	Waybill, Consist, or Bill of Lading	With the conductor	Conductor
Water	Dangerous Cargo Manifest	Wheelhouse or pipelike container on barges	Captain or Master
Airplane	Air Bill with a Shipper's Certification for Restricted Articles	Cockpit**	Pilot

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* Manufacturer's data sheets are generally available from the driver as well.

** This also may be found attached to the outside of the package.

The law says that manufacturers must have *Material Safety Data Sheets (MSDS)* for every chemical at a facility. The law further requires that these data sheets are to be provided to the LEPC, the SERC, and the fire department having jurisdiction over the facility. These information sheets could prove invaluable.

The *Chemical Abstract Service,* available through the American Chemical Society, has the world's largest information file on substances, and it is updated weekly. It permits retrieval of information about a chemical formula, structure, name, and more on 6.5 million known products. Any material evaluated and listed is provided its own reference identification, a "social security" number of sorts, called a CAS number.

The *Registry of Toxic Effects and Chemical Substances (RTECS)* published by NIOSH is useful in finding toxicological information. Like the Chemical Abstract Service, RTECS data may be obtained by referencing either a product name or a RTECS number.

CHEMTREC

The Chemical Transportation Emergency Center (CHEMTREC) of the Chemical Manufacturers Association is a 24-hour emergency response information service. Its staff will provide contact with both manufacturers and shippers. It will not resolve a hazardous materials incident but will furnish information and establish communication.

SITE PERSONNEL

Carrier or facility personnel may be of enormous help. The drivers, the foremen, the managers, the supervisors, the engineers, or the shippers may be able to provide some very helpful information on the product and its associated hazards.

SENSES

Finally, our own senses can help in identification. Learn to be an observer; make note of the unusual. Pay attention to sights, sounds, and odors, but remember that sights, sounds, and odors should be seen, heard, and smelled from a distance. Get only as close as you safely can to get information, not to get hurt.

APPENDIX E

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