October 16, 1986, President Ronald Reagan signed the Superfund Amendment Reauthorization Act. Title I Section 126 of this Act mandated that training requirements be developed and adopted by the Occupational Safety and Health Administration and the Environmental Protection Agency. On March 6, 1989, OSHA published their final rule in the Code of Federal Regulations Title 29:1910.120. EPA followed on June 23, 1989, by adopting their rules in the Code of Federal Regulations Title 40:311.1. OSHA adopted their rule using the National Fire Protection Associations Standard 472 as a guide.

OSHA's 29 CFR 1910.120 and NFPA 472 standards set forth a tiered level of training and response for Hazardous Materials Emergencies. The levels are as follows:

1. First Responder Awareness Level - is someone who may witness a release and make proper notification.
2. First Responder Operations Level - is someone who may respond to a Hazardous Materials Emergency but in a defensive fashion.
3. Hazardous Materials Technician - is someone who may respond to a Hazardous Materials Emergency in an offensive fashion.
4. Hazardous Materials Specialist - is someone who may respond with a Hazardous Materials Technician to an incident with specialized product knowledge.

This manual was compiled to assist the emergency responder in achieving the above levels of training. It is to be used in conjunction with lectures, practical exercises and the showing of competencies in the areas set forth by the law.

The Hazardous Materials field is ever changing. In order to maintain the quality of response, the responder must continually train and update his resources. The persons responsible for this manual sincerely hope that it provides the information necessary to respond efficiently and safely.

TABLE OF CONTENTS

HAZARD RECOGNITION

I. Introduction

A hazardous materials incident is a situation in which a hazardous material is or may be released into the environment. Emergency response personnel are expected to handle a hazardous materials incident safely and efficiently. In order to do this the responder must assess the hazards of the hazardous material and the potential danger that it poses. Hazardous materials are produced, stored, and shipped through practically every community. The incident may come in the form of a large multi-storage facility fire and explosion or as simple as a one ounce spill of an etiological agent. No matter the size of the incident, the responder should have in place a set of operating procedures that will assure the correct assessment and action every time.

There are five broad, interacting elements which are required when responding to hazardous materials incidents.

1. **Recognition:** Identification of the substance involved and the characteristics which determine its degree of hazard.
2. **Evaluation:** The impact or risk the substance poses to public health and the environment.
3. **Control:** Methods to eliminate or reduce the impact of the incident.

4. **Information:** Knowledge required concerning the conditions or circumstances particular to an incident. Information gathered in a response should be disseminated.
5. **Safety:** Protection of responders from harm.

The task in response work is to prevent or reduce the impact of the incident on people, property, and the environment, and to restore conditions to as near normal as possible.

Response personnel must perform a variety of activities, often simultaneously, to achieve these goals. The five elements if integrated into an orderly arrangement will comprise a workable system. Keep in mind these activities are all related; what occurs in one affects or is affected by the others.

II. Recognition

The identification of the hazardous material is usually one of the first steps in a response. Making this identification allows the responders to assess the type and degree of hazard present. Recognizing hazards may be easily accomplished by using, the placarding or labeling system, shipping papers or documents, or a verbal interview with the handler or shipper. The responder must use all available information to identify the substance(s).

Some of the common clues are visual observation, monitoring instruments readings, witnesses, container shapes and sizes, historical data, location, and any other source possible. The proper identification is critical. Once the substance is identified, the responder can look at the physical and chemical properties to help predict the behavior and anticipated problems with the substance. An example would be the specific gravity of a solid or liquid or the vapor density of a gas. This will tell if the substance is going to float or sink in water or rise or fall in air.

An incident involves more than just the presence of a hazardous material. Problems caused by the release of a particular substance are dictated by site specific conditions. The same substance released in two different areas or climates may react differently. Thousands of substances exhibit one or more characteristics of flammability, radioactivity, corrosiveness, toxicity, or other properties which classify them as hazardous. The degree of hazard is a relative measure of how hazardous a substance is and varies depending on the substance. For example, the Immediately Dangerous To Life or Health (IDLH) concentration of carbon dioxide is 50,000 parts per million in air; the IDLH for chlorine is 25 parts per million in air. Chlorine is much more acutely toxic when inhaled at the same concentrations as carbon dioxide. The responder must know his reference material and monitoring instruments and what they are telling him. In the above example the smaller the number the greater the hazard.

Once the substance(s) are identified and their hazardous properties and the degree of hazard have been determined, the response team can begin its risk assessment and formulate the plan to mitigate the incident.

III. Evaluation

Recognition provides basic data concerning the substance. Evaluation is determining its effects or potential impact on public health, property, safety of the response team, and the environment. The physical and chemical characteristics of a hazardous material cause the threat. The actual impact depends on the location of the release, the weather, the terrain, and other site specific conditions. Impact of a substance is considered in two ways: what has already occurred or what may occur, the potential impact. Risk is the probability of harm being done or a measure of the potential impact. The presence of a hazardous substance presents a risk; but if the material is under control, the risk is low; if uncontrolled the risk increases. For harm to be done, a critical receptor must be exposed to the material. A critical receptor can be anything from humans to a sensitive ecological habitat. The degree of harm is controlled by the chemical and physical properties of the material, and its exposure to the critical receptor. In order for the evaluation to be complete, the response team must have reliable information.

One of the most effective tools concerning recognition and evaluation is the incident or site pre-plan. The pre-plan is invaluable. It allows the responders to know products, specifics, and locations. It also shows routes into and out of the areas. The response team will know the capabilities of a particular jurisdiction or facility, including equipment and man power. Preplanning should be done prior to an incident. It should be prepared by response personnel and kept in a conspicuous location-easily accessible.

During an emergency all the aforementioned activities are usually going on simultaneously. The response team has numerous decisions to make in a short time to begin the initial size up. A word of caution to the responder or response team is: do not allow the size of the incident, public sentiment, outside pressure, or an unknowledgeable supervisor force you into action unless the proper recognition and evaluation have been done. It is critical to you, the response team, as well as the people and environment around the incident to have a standard operating procedure and to use it.

IV. Control

Control is those methods which prevent or reduce the impact of the incident. Control actions are generally instituted as rapidly as possible in emergency situations. As information is developed through recognition and evaluation, the initial control plans are modified or others put in place. Each incident will dictate its own controls, because of specifics of a product and site characterization. Certain types of releases do not require immediate action.

These releases allow more time for planning and instituting remedial actions. Control measures include physical, chemical, and biological treatment and cleanup techniques for restoring the area to pre-release conditions. It also concerns public health counter-measures; such as, an evacuation or the shutdown of a drinking water supply. This control is to prevent contact of the substance and people.

V. Information

Information is an important component of the response effort. All response activities are based upon having information that is readily available or subsequently obtained. Information, discussed here, is a support element to recognition, evaluation, and control. We gathered and used information during the initial steps, but we need additional information at this point. Surely we can use what was obtained in the initial steps, but new information may change the entire approach. Information is an input into the performance elements, providing data for decision making. It is also an outcome of these elements. A sample is collected and analyzed. The results provide input to determine treatment options, an outcome. Information comes from three sources:

Intelligence: Information obtained from existing records or documentation, placards, labels, signs, special configuration of containers, visual observations, technical reports, MSDS, shipping papers. and any other source.

Direct Reading Instruments: Information relatively quickly obtained from instruments. A word of caution--one must know and understand the instrument he is using.

Sampling: Information obtained from collecting representative portions of appropriate material for subsequent laboratory analysis.

Information acquisition, analyses, and decision making are interlinked processes that define the extent of the problem and the options for possible response actions. The information base must be accurate, valid, and timely in order for it to be effective. A stream of information is collected, processed, and applied throughout the life time of an incident. A channel for this flow should be established in the standard operating procedure and the sites preplan. Decisions being made are based on this plan.

VI. Safety

Response to hazardous materials incidents poses varying dangers to responders. To protect the health and safety of the responders is an important consideration in all response activities. To do this, the responder has to apply the information gathered, requiring that the chemical and physical hazards associated with each operation be assessed and methods implemented to prevent or reduce harm to responders. Safety considerations are an input to every activity that is undertaken and are an outcome of each response activity. Example: an outcome of identifying a specific chemical may be changes in safety requirements. The safety issue must be addressed at all levels. Each activity is analyzed as a small incident, applying all the information gathered in order to accomplish a task so that its accomplishment fits into the plan of the overall incident. All response organizations must have an effective health and safety program including medical surveillance, health monitoring, appropriate safety equipment, standardized safety procedures, and an active training program. Each response team should designate a safety officer to oversee this function.

VII. Summary

Recognition, evaluation, control, information, and safety are the five elements of response. Each includes a number of activities or operations which may take place simultaneously or one at a time. These elements are not necessarily chronological for responding. Control measures maybe started before the substances are completely identified and their initial controls updated as more information is channelled through the evaluation process. Another example usually of utmost concern, safety measures for responders may be instituted before the materials are identified or all the hazards fully known.

Each element and activity is interrelated.

Example: A dike (control) to contain the runoff water from fire fighting at a warehouse suspected of containing pesticides, is built. It is determined that the runoff contains no hazardous chemicals (recognition), or that concentrations in the runoff are below acceptable values (evaluation); no treatment is necessary and the dikes can be removed. This knowledge (information) also changes the safety plan for responders (safety).

Information flow should be constant and is needed to properly characterize the incident and to make decisions. The flow of information should be up and down the chain of command. Information obtained but not disseminated is of no use. The organization's standard operating procedure and a site preplan should allow for this flow of information.

The response system is a concept explaining in general terms, the processes involved in incident response. All responses require the performance elements of recognizing, evaluating, and controlling. To support these, information is needed and responder safety must be considered. As a responder, your actions or reactions should always be directed by the incident itself; i.e., no two incidents are exactly alike. Some are very similar but each must go through the recognition and evaluation status in order to set controls and gather information to implement proper safety precautions.

IDENTIFICATION

I. Introduction

In response to hazardous materials emergencies, one of the primary objectives of responders is to positively identify the products involved in the emergency. This can be done in several ways. There are many different labeling systems used in the hazardous materials field and to properly identify these materials one must understand the differences between these systems. We will look at the Department of Transportation's (DOT) classification system and the NFPA 704 labeling system in detail because these are two of the most used systems and are likely to be encountered by responders.

Labels are not the only way to identify the possible hazardous materials in an emergency. The responder needs to locate the shipping papers, MSDS sheets or any other documents in order to identify the materials. The location, size, and shapes of containers will also provide valuable information in the identification process.

II. Department of Transportations Hazard Classes.

The DOT's system for labeling materials is probably the most used system of all. (It is designed for use in transportation of hazardous materials; however this system can be seen at fixed site facilities.) When this system is used for anything other than transportation--and even then--it has many limitations. The DOT divides hazardous materials into nine major classes:

1. Explosives
2. Compressed Gases
3. Flammable/Combustible Liquids
4. Flammable Solids
5. Oxidizers
6. Poisons
7. Radioactive Materials
8. Corrosives
9. Other Regulated Materials. (ORM)

1. <u>Explosives</u>: Materials which function by a rapid release of energy; these materials are designed to explode.

    1. Characteristics

        a. Heat and shock sensitive

        b. Sensitive to contamination

        c. Thermal/mechanical effect

    A. Categories

        1. Class A: Maximum hazard, function by detonation. The shock waves will travel faster than the speed of sound.

           Examples: Dynamite, TNT.

        2. Class B: Materials which function by rapid burning known as deflagration. Unlike Class A explosives, the shock waves of these materials

travel slower than the speed of sound.

Examples: Rocket propellants.

3. Class C: Materials which contain Class A or Class B explosives packaged in small quantities. These materials can be carried in a box truck in large amounts and placarded "Dangerous." Simply packaging Class A or B explosives as firecrackers or bullets should make little or no difference to the first responder.

   Examples: fireworks, ammunition.

4. Blasting Agents - These material are harder to detonate than Class A or B explosives, but upon detonation can cause the same amount of massive destruction achieved in the other classes.

   Examples: ammonium nitrate, fuel oil mixture.

B. Response

In responding to emergencies involving explosives extreme caution must be used. Containers holding explosives, involved in a fire, should be allowed to burn if at all possible. This type of incident will generally dictate a defensive posture by responders.

2. **Compressed Gases:** Materials in a container under pressure.

A. Characteristics

1. B.L.E.V.E. (Boiling Liquid Expanding Vapor Explosion)

2. Flammable

3. Toxic

4. Highly mobile

5. Expansion ratios (Liquids)

6. Frost bite (Liquids)

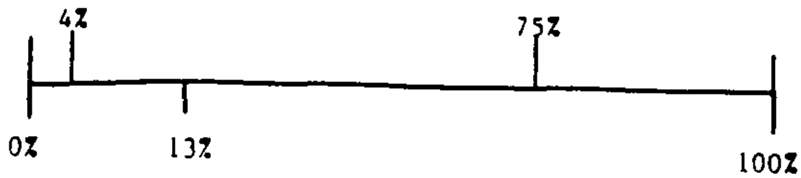
B. Categories

1. Flammable gases: Gases having a LEL (Lower Explosive Limit) of less than 13% or having a flammable range wider than 12 percentage points are considered to be flammable.

   The flammable range is the amount of product in air that will burn. The smallest amount in air that will burn, is the LEL and the highest amount in air that will burn is the UEL.

   Example: Concentrations in air.

Hydrogen

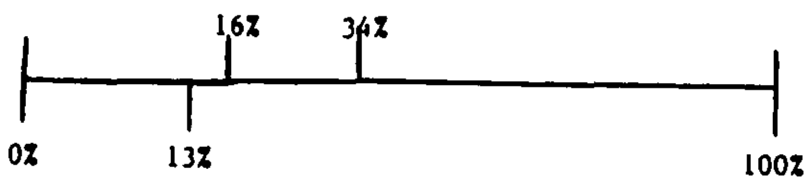


Hydrogen meets both criteria set down by the DOT for being a flammable gas.

Methane

Methane, meets the criteria of having a LEL less than 13%, therefore it is classed as a flammable gas.

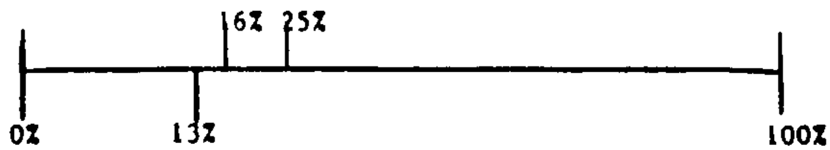
Trifluorochloroethylene



Trifluorochloroethylene meets the criteria of having a flammable range wider than 12 percentage points, therefore it is classed as a flammable gas.

2. Nonflammable gases: Materials which do not meet the DOT's criteria for flammable gases. This classification can and does have gases that will burn.

Example: Sulfur dioxide, nitrogen, anhydrous ammonia

Anhydrous Ammonia 

Anhydrous Ammonia will burn in a concentration between 16% and 25%. This flammable range does not meet the DOT's criteria for flammable gases therefore it will fall into the non-flammable gas category.

3. Poisonous gases: Materials that are in a gaseous state under normal conditions pose an extreme hazard because of their toxicicity to humans.

   Examples: chlorine, phosgene.

C. Response

The difficulty of handling materials in a vapor state along with the different characteristics of compressed gases make emergency situations difficult to handle. Responders should obtain additional information on the specific material(s) involved. Fires are generally put out by shutting off the flow of the gas while other considerations need to be made for poisonous and non-flammable gasses. Due to their toxicity or capability of displacing the oxygen, an evacuation of the public may be needed.

3. **Flammable or Combustible Liquids:** Liquids which have a flash point of 200°F or less. The flash point is the lowest temperature that a liquid will give off ignitable vapors.

A. Categories

1. Flammable liquids - Liquids with a flash point below 100°F.

Examples:

Methyl Alcohol	FL.P.	61°F
Acetone	FL.P.	4°F
Gasoline	FL.P.	-40°F

2. Pyroforic liquids - Liquids which will spontaneously ignite in air at or below 140°F.

Examples:

Pentaborane

Aluminum alkyls

3. Combustible liquids - Liquids which have a flash point between 100 and 200°F.

Examples:

Kerosene	FL.P.	100°F
Diesel fuel	FL.P.	140°F

B. Response

Flammable or combustible liquids are the most likely class of hazardous materials to be encountered by the emergency responder. Fires involving these liquids often require the use of foam for extinguishment and suppression of vapors, also damming and diking procedures should be done to prevent runoff.

4. **Flammable Solids**: Solids other than explosives which could cause fires through friction, retained heat from manufacturing or processing, or which can be ignited readily and when ignited burn so vigorously as to create a serious transportation hazard.

A. Categories

1. Flammable Solids

   Examples: Magnesium
   Titanium

2. Water Reactive

   Examples: Potassium
   Sodium

3. Spontaneously Combustibles

   Examples: Sodium
   White phosphorus

B. Response

Flammable solids have many of the same characteristics as explosives; however they are not designed to be an explosive. These materials are difficult for the average responder to handle. The exact product along with its characteristics should be known prior to any offensive action being taken. If a fire is involved, water could increase rather than decrease the intensity of the fire. The initial objective of responders in these emergencies should be the isolation of these materials to prevent further damage.

5. **Oxidizers**: Products which yield oxygen readily to stimulate combustion of organics.

   A. Characteristics

      1. Heat and shock sensitive
      2. Unpredictable
      3. Problems with contamination
      4. Reactivity

   B. Categories

      1. Oxidizers

         Examples: oxygen, calcium hypochlorite

      2. Organic peroxides - a derivative of hydrogen peroxide containing the bivalent -0-0- where one or more of the hydrogen atoms have been replaced by organic radicals. These materials are thought of as being unstable and like

oxidizers have many characteristics of explosives in an emergency.

Example: benzoyl peroxide

C. Response

Emergencies involving oxidizers are very unpredictable. Products that generally do not burn, now can; and products that readily burn quite often, become explosive. Many of these materials will end in the letters - ite or ate. If a responder encounters one of these names such as permangan**ate** or chlor<u>ite</u>, he should expect some type of oxidizing potential of the product. Isolation of these products from other combustible materials is a primary concern in an emergency.

6. **Poisons:** Materials which cause harm to living organisms either through inhalation, absorption, injection or skin contact.

A. Categories

1. Poison A - gases or liquids in which a very small amount of the vapors is dangerous to life.

   Examples: phosgene
   arsine

2. Poison B - liquids, sludges, and solids which afford a hazard to health during transportation.

Examples: parathion
methyl bromide

3. Irritating Material - materials other than poisons A & B which give off intensely irritating fumes.

   Example: Tear gas

4. Etiological agents - viable micro-organism or their toxins which causes or may cause human disease

   Examples: Botulism
   AIDS virus
   Anthrax

C. Response

Poisons have caused the largest hazardous materials evacuations on in North America; poisons also caused the worst hazardous materials emergency in the world at Bophal, India. Evacuation is a primary concern of affected areas for responders in a poison vapor emergency. This may not always be the answer due to the time needed to evacuate. Shelter-in place procedures, while the leak is being stopped or controlled, may be the proper action to be taken.

7. **Radioactive Materials:** Materials that spontaneously emit ionizing radiation.

A. Characteristics

There are three basic types of radiation alpha, beta, and gamma-each possessing different properties. Alpha and beta radiation are particulate and unless airborne, do not pose so great a hazard as gamma. Gamma radiation is an electromagnetic wave which will cause the most harm to responders. One cannot detect radiation by any of the human senses and normal protective gear will afford no protection from gamma rays.

B. Categories

1. Radioactive I

Materials which register 0.5 millirems per hour or less on the external surface of the container.

2. Radioactive II

Materials which register less than 1 millirem per hour at 3-ft from external points of the container.

3. Radioactive III

Materials which register more than 50 millirems per hour at external surface or more than 1 millirem 3 ft. away from package surface.

C. Response

When responding to a radiological emergency one should first get a background reading of radioactivity of the surrounding area. Once background is established, any reading above background is cause for extreme caution. A reading obtained of 1 M/R per hour above background would dictate immediate isolation of the area and contacting the proper authority having jurisdiction to handle the situation (i.e., Department of Environmental Quality, Nuclear Regulatory Commission, or Department of Health, etc.)

8. <u>Corrosives:</u>

Liquids are solids which cause damage to human tissue or have a severe corrosion rate on steel.

A. Categories

1. Acids: products having a pH less than 7 on the pH scale 0-14.

2. Alkalies (bases): products having a pH greater than 7 on the 0-14 pH scale.

B. Response

Corrosives are involved in 1/3 of all hazardous materials emergencies, second only to flammable or combustible liquids. Liquids should be contained for pick up and disposal if possible rather than trying to neutralize these products in the field. Neutralization can be accomplished in a laboratory environment quite effectively with relative ease; however in the field many unknown factors come into play (i.e., product amount, humidity in air, concentration of product). Removing the materials for disposal at a treatment facility is often the proper action.

9. **Other Regulated Materials:** Materials which do not fit into the classes listed above but because of their characteristics require special handling during transportation. This is sometimes considered the miscellaneous class.

   A. Categories

      1. ORM-A - Materials with anesthetic, irritating, noxious, toxic, or other similar properties can cause extreme annoyance or discomfort to those exposed.
      2. ORM-B - Materials capable of causing significant damage to a transport vehicle in the event of a leak during transportation.
      3. ORM-C - Materials which have characteristics requiring special handling requirements but do not fit into ORM A or ORM B categories.

4. ORM-D - Consumer commodities which present a limited hazard during transportation.
5. ORM-E - Hazardous waste.

III. DOT(s) Placarding & Labeling System

Hazardous materials while in transportation may require placards or labels depending on the quantity shipped. Materials are divided into two categories, Table I and Table II. Products in Table I must be placarded regardless of their amounts. Table II products must be placarded if over 1000 pounds are present. Products in Table II can and will be transported with no placards if below the 1000 pound limit.

Table I

Explosives A

Explosives B

Flammable solids water reactive

Poisons A

Radioactive

Table II

Explosives C

Blasting agents

Compressed gases

Flammable/combustible liquids

Flammable solids

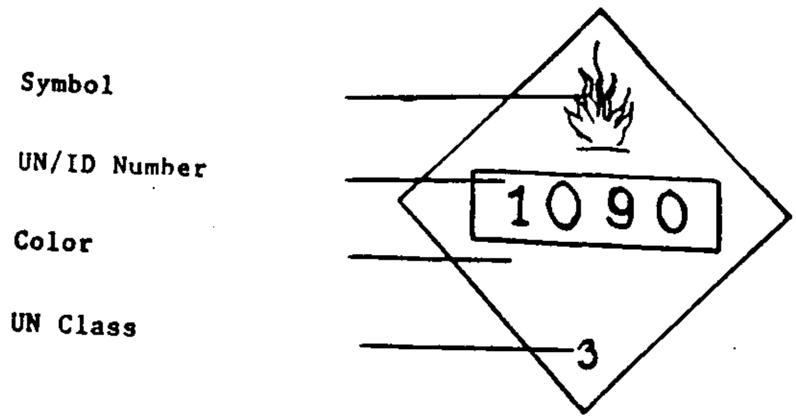
Oxidizers

Poisons B

Corrosives

Placards are designed to have four main identification characteristics:

1. Color of the placard
2. Symbol at the top of the placard
3. UN/ID number-4 digit number in the center of the placard
4. UN Clas - found at the bottom of the placard.



Colors of placards

a. Explosives - orange
b. Compressed gases
    (1) Flammable - red
    (2) Nonflammable - green
    (3) Poisonous - white
c. Flammable and Combustible liquids - red
d. Flammable solids - Red and white striped
    (1) Water reactive - blue section.
e. Oxidizers - yellow
f. Poisons - white

g. Radioactive - yellow and white

h. Corrosives - black and white

Dangerous Placards: used to indicate Explosives C, irritants, or a mixed load of Table II products. When this placard is used, obviously much more information is needed.

IV. Shipping Papers

Hazardous materials, when in transportation must have some type of identification papers with them. For highway transportation the documents, called shipping papers, will be found in the cab within arm's reach of the driver. Should the driver leave the truck, the law requires the shipping papers to be placed on the drivers seat or in the drivers door side pocket. For rail transportation, the documents are called consists and way bills. A consist is the makeup of the train listing the cars in order (either front to rear or rear to front), (depending on the railroad), including the car identification number. Way bills (sometimes called wheel reports) furnishes information on individual cars consisting of car identification number, product, amount, shipper, and consignee.

In a transportation emergency, these identification papers will give the first responder more detailed information, detailing product names, amount shipped, shipper, carrier, and consignee.

V. NFPA 704 Labeling System

The National Fire Protection Associations 704 Labeling System is designed for use at fixed site facilities. Though the system provides information about the properties of the product, it fails to identify the product specifically. It gives the characteristics of the product. The NFPA 704 system is divided into 4 categories: flammability (red), health (blue), reactivity (yellow), and special information (white). In the flammable, health and reactive sections of the label a number will be present from 0 to 4. These numbers indicate the severity of the hazards, 0 being the least hazard and 4 being the highest hazard.

B. Summary of hazard ranking system

1. Health hazard (blue)

Rank Number	Description
4	Materials that on very short exposure could cause death or major residual injury even though prompt medical treatment was given.
3	Materials that on short exposure could cause serious temporary or residual injury even though prompt medical treatment was given.
2	Materials that on intense or continued exposure could cause temporary incapacitation or possible residual injury unless prompt medical treatment was given.

1	Materials that on exposure would cause irritation but only minor residual injury even if no treatment was given.
0	Materials that on exposure under fire conditions would offer no hazard beyond that of ordinary combustible material.

2. Flammability hazard (red)

Rank Number	Description
4	Materials that (1) rapidly or completely vaporize at atmospheric pressure and normal ambient temperatures and burn readily or (2) are readily dispersed in air and burn readily.
3	Liquids and solids that can be ignited under almost all ambient temperature conditions.
2	Materials that must be moderately heated or exposed to relatively high ambient temperatures before ignition can occur.
1	Materials that must be preheated before ignition can occur.
0	Materials that will not burn.

3. Reactivity hazard (yellow)

Rank Number	Description
4	Materials that in themselves are readily capable of detonation, of explosive decomposition, or reaction at

normal temperatures and pressures.

3 Materials that (1) in themselves are capable of detonation or explosive reaction but require a strong initiating source, or (2) must be heated under confinement before initiation, or (3) react explosively with water.

2 Materials that (1) in themselves are normally unstable and readily undergo violent chemical change but do not detonate, (2) may react violently with water, or (3) may form potentially explosive mixtures with water.

1 Materials that in themselves are normally stable but which can (1) become unstable at elevated temperatures or (2) react with water with some release of energy, but not violently.

0 Materials that in themselves are normally stable, even when exposed to fire, and that do not react with water.

4. Special information (White)

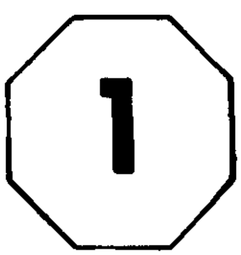
The white block is designated for special information about the chemical. For example, it may indicate that the material is radioactive by displaying the standard radioactive symbol, or water-reactive by displaying a large W with a slash through it. For a more complete discussion of these various hazards, consult the NFPA 704 Standard.

VI. Military Marking Systems

The United States Military has established their own system for labeling hazardous materials. This system is used on military bases but quite often no markings will be on the transport vehicle. The seven symbols used in the military are:

1. **Chemical hazard**
2. **Apply no water**
3. **Wear protective mask or breathing apparatus**
4. **Mass detonation - Class 1**
5. Explosion with fragments - Class 2
6. Mass fire hazard - Class 3
7. Moderate fire hazard - Class 4





VII. Pesticide Labels

Pesticide labeling - labeling on a pesticide label must contain several items used to identify and classify the pesticide. The following items should be included on a pesticide label.

1. Name of pesticide - for identification (usually a trade name)

2. Signal Word (relative to other pesticides)
   Danger - highest hazard
   Warning - moderate hazard
   Caution - low hazard

3. EPA Registration number - for identification of all products contained.

4. Precautionary statement - how to handle pesticide

5. Hazard statement - possible problems of exposure

6. Active ingredient - specific chemical name

VIII. Containers of Hazardous Materials

A. Non-bulk containers used to carry hazardous materials

1. Bags carry oxidizers, poisons (i.e. pesticides), and ORM's.

2. Bottles - generally carry various liquids falling into several hazard classes such as flammable and combustible liquids, oxidizers, poisons and corrosives.

3. Boxes - carry solids from the explosives, flammable solids, oxidizers, and poisons categories. They will sometimes have a plastic liner which enables them to carry various liquids.

4. Cans - carry liquids and solids from the explosives, flammable and combustible liquids, flammable solids, oxidizers, and poisons.

5. Carboys - used to carry corrosives because of their ability to withstand the corrosive effects of these materials. Usually made of a glass jar type inner container with some type of overpack protective covering.

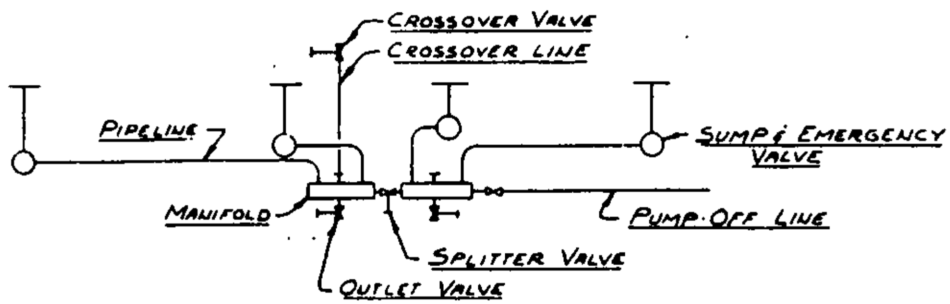
6. Cylinders - carry compressed gases because of their ability to withstand high pressures.

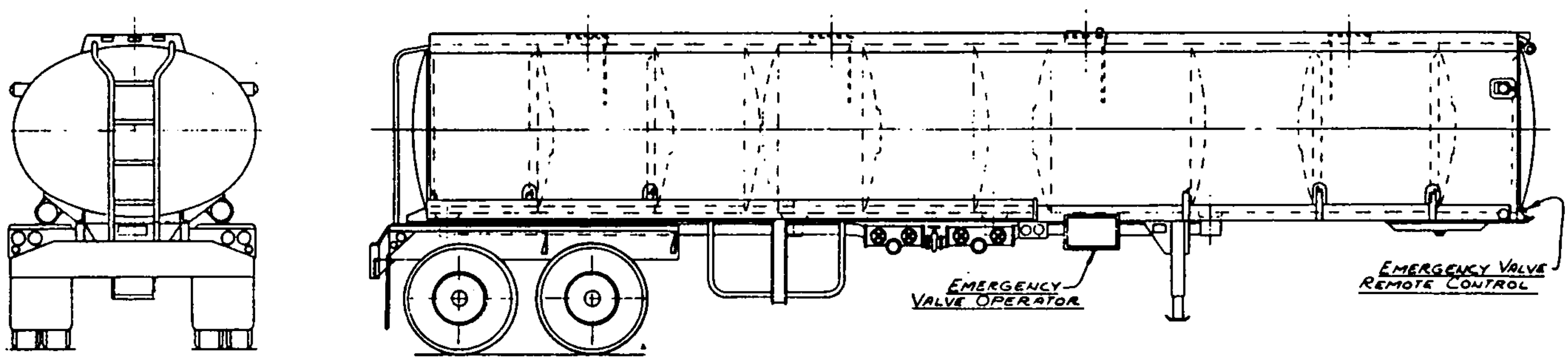
7. Drums - carry various liquids from the flammable combustible liquids, oxidizers, poisons, corrosives and ORM classes. Usually metal but sometimes made of plastic to withstand certain products.

8. Fixed tanks and intermodal tanks - carry various liquids and sometimes gases from the compressed gases, flammable and combustible liquids, oxidizers, poisons, corrosives and ORM classes.

B. Bulk Containers

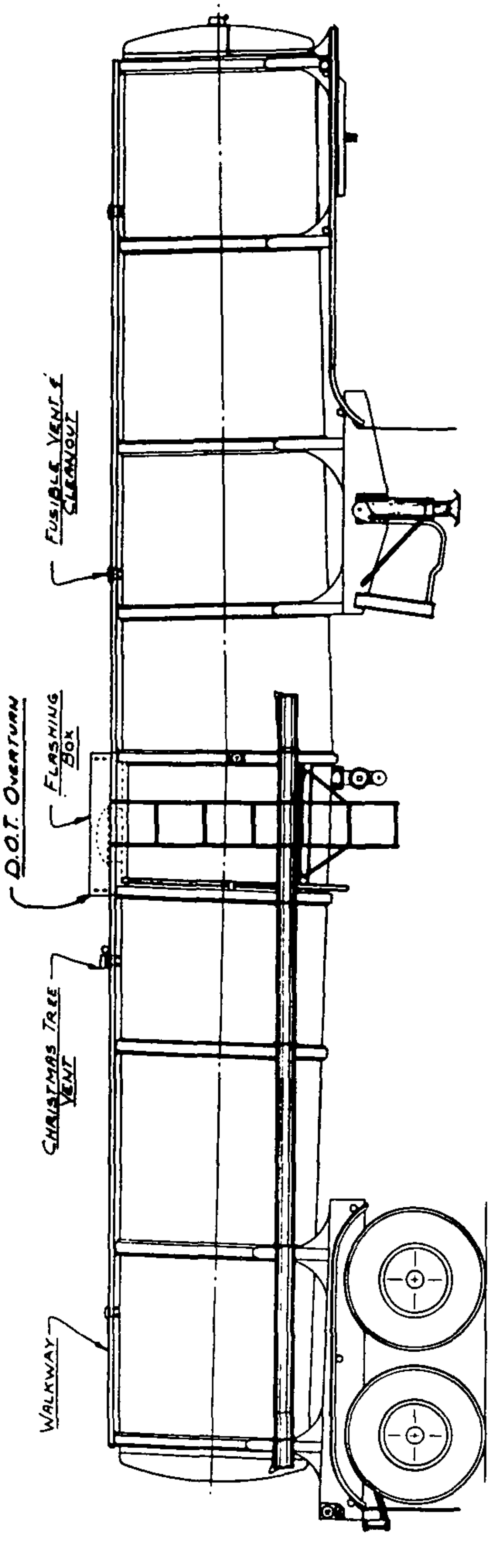
The following diagrams are examples of tank truck and tank cars which carry hazardous materials.


CROSSOVER VALVE
CROSSOVER LINE
PIPELINE
SUMP & EMERGENCY VALVE
MANIFOLD
PUMP-OFF LINE
SPLITTER VALVE
OUTLET VALVE

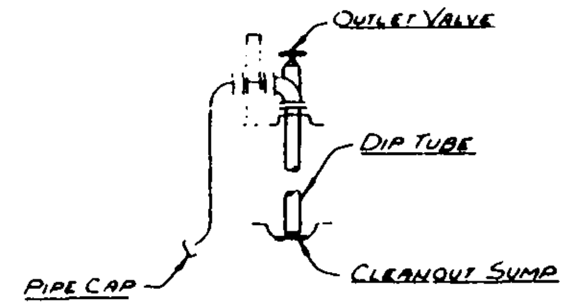

EMERGENCY VALVE OPERATOR
EMERGENCY VALVE REMOTE CONTROL

MC-306

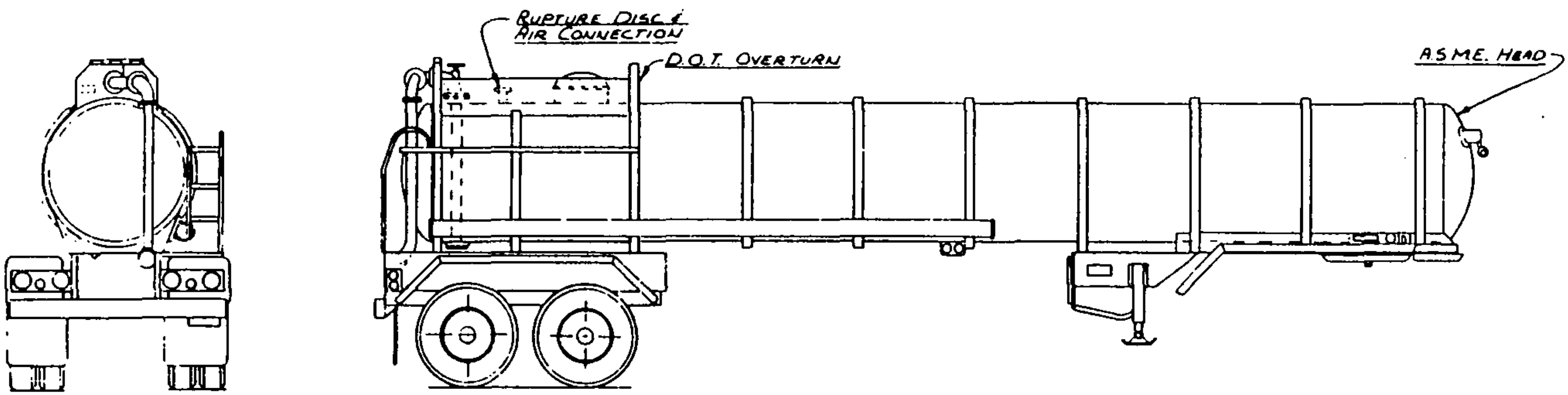
ABD00162350



TYPICAL MC-307

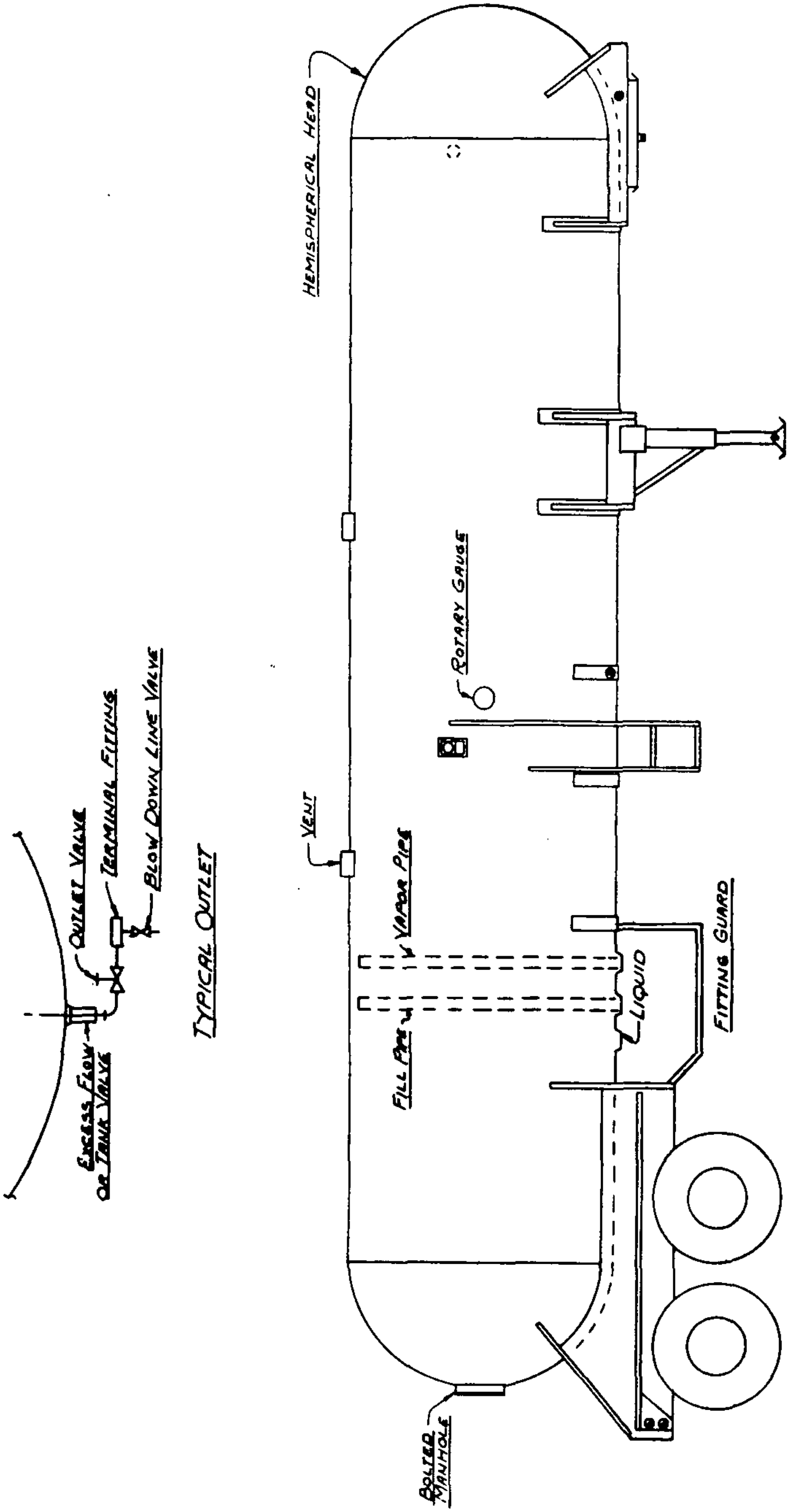


PIPING



MC-312 PRESSURE TRANSPORT

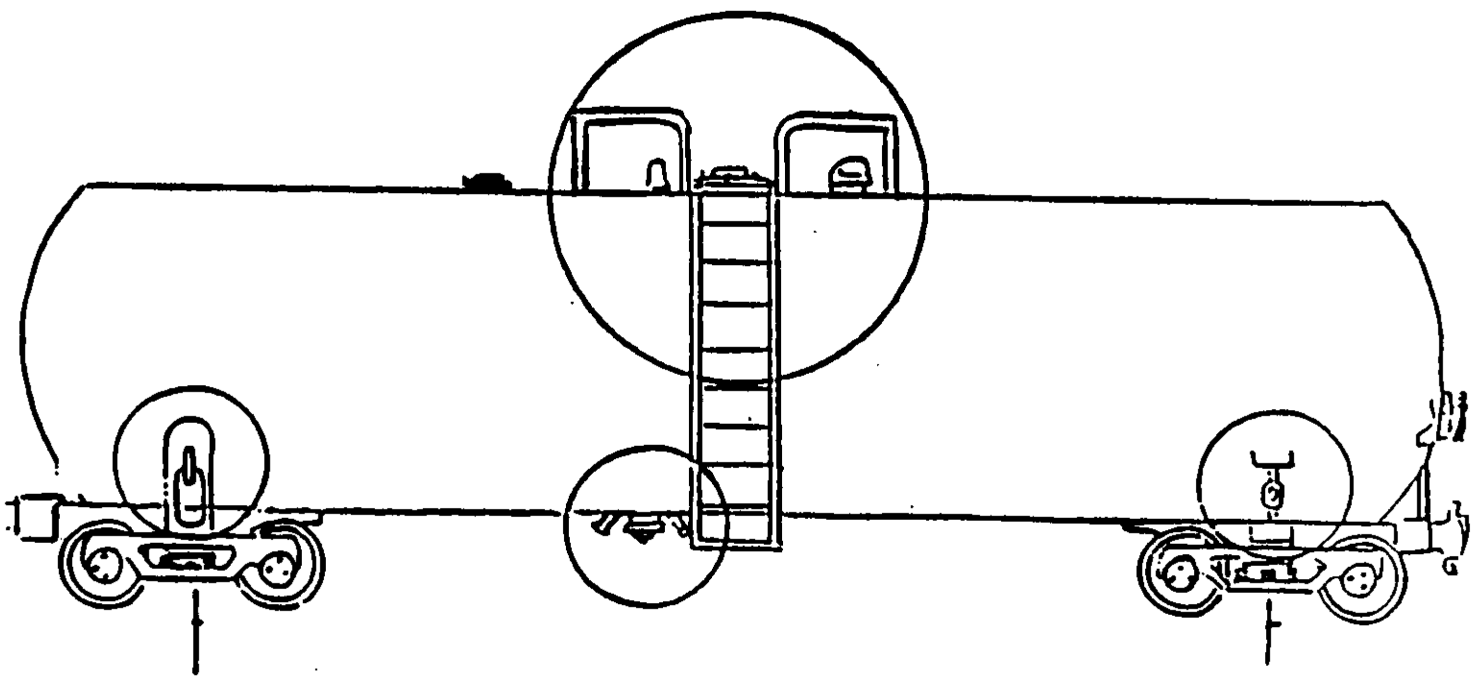
ABD00162351


HEMISPHERICAL HEAD
ROTARY GAUGE
VENT
VAPOR PIPE
FILL PIPE
LIQUID
FITTING GUARD
BOLTED MANHOLE
OUTLET VALVE
TERMINAL FITTING
BLOW DOWN LINE VALVE
EXCESS FLOW OR TANK VALVE
TYPICAL OUTLET

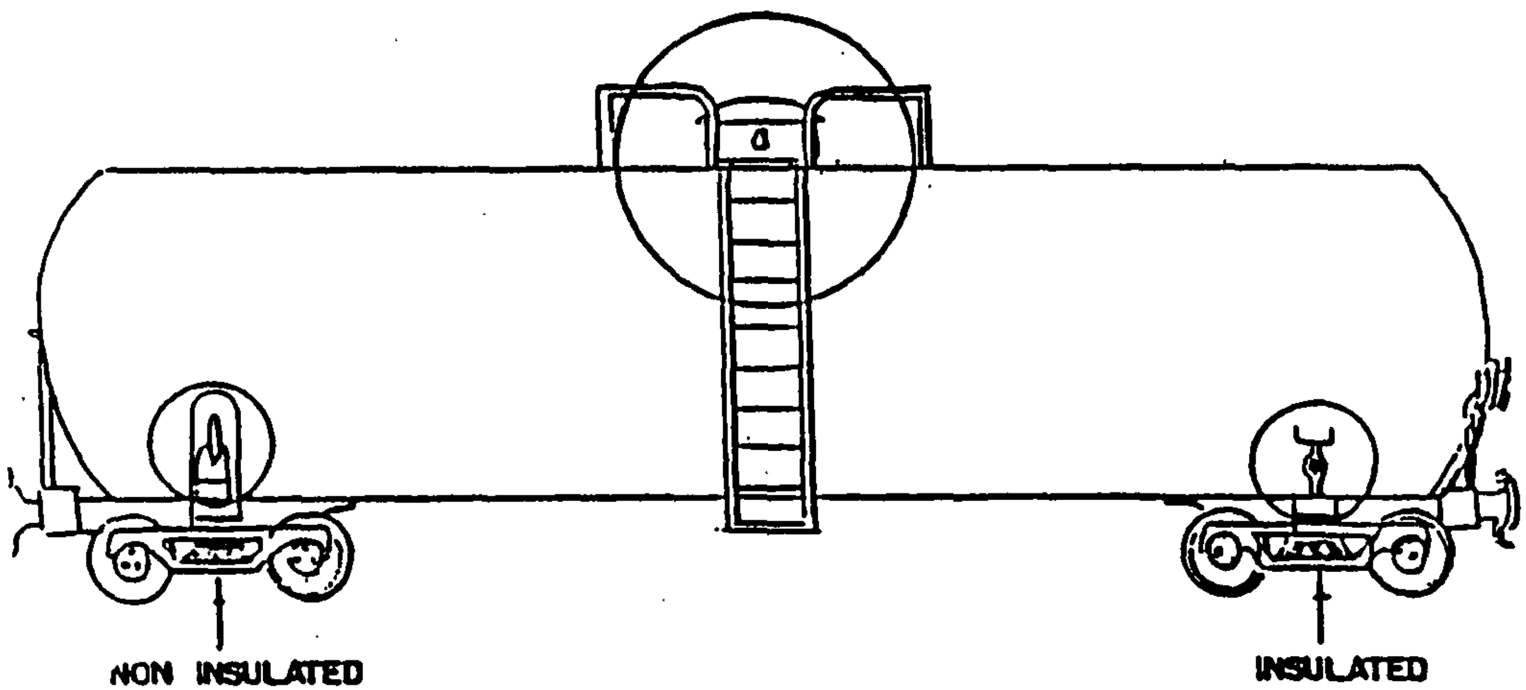
MC-331

GENERAL SERVICE

NON ---PRESSURE



COMPRESSED GAS PRESSURE



PRINCIPLES OF TOXICOLOGY

I. Introduction

It is important that first responders have a basic understanding of how chemicals can harm them in order to make effective decisions during hazardous materials incidents. The science that studies this field is referred to as toxicology. In the past, toxicology was commonly referred to as the "Science of Poisons." This classic connotation has been expanded in recent years; now the science is referred to as the study of the interaction between chemical agents and biological systems.

As chemicals are studied, we are constantly reaffirming an observation made in early years by Paracelsus (1493-1541) that "All substances are poisons; there is none which is not a poison only the dose differentiates a poison from a remedy." First responders should constantly remind themselves of the observation's and the validity. A good illustration would be: two aspirin may be taken to cure a headache, yet two bottles of aspirin could be lethal. Because the toxicity of a chemical is always directly related to its dose, we should not refer to chemicals as toxic unless we give the dose that a response or effect occurs for that chemical.

To apply these principles to hazardous materials emergencies, we must understand the routes a chemical can enter, the fate of a chemical once inside, the type of harm that can be done to the body; commonly used dose terms and factors that influence toxicity.

II. Route of Exposure

The manner in which a chemical enters the body can greatly influence the potential damage it can cause. There are four possible routes of exposure to chemicals: inhalation, ingestion, absorption through the skin, and injection. While exploring each of these possible routes of exposure one must note that many chemicals can produce harmful effects through more than one of these routes. Example: hydrogen cyanide - (1) inhaled at low concentrations, can be deadly; (2) can cause death by being absorbed through the skin.

A. Inhalation - the breathing of airborne contaminants in the form of vapors, gases, mists, or particulates may produce harmful effects.

   1. Effects - two effects can occur when chemicals are inhaled locally or systemically.

      a. Local damage can occur to the respiratory tract by the direct contact with certain chemicals such as corrosives. Our respiratory system is the only organ system with vital functional elements in constant, direct contact with the environment. The lungs have a surface area of 70 to 100 square meters versus 2 square meters for the skin. A large percent of this surface area is alveoli sacs with very thin and sensitive walls filled with bundles of capillaries.

b. Systemic effects are those that occur away from the site of entry into the body. Systemic damage can easily occur when certain chemicals are inhaled. These products pass through the thin walls of the alveoli sacs into the blood stream and are then transported throughout the body where they can produce harmful effects.

2. Types of Inhaled Toxicants

The following toxicants are classified according to how they affect the respiratory tract.

a. Asphyxiants: gases that deprive the body tissues of oxygen.

1. Simple asphyxiants are those materials that are not toxic in low levels but can produce harmful effects by diluting or replacing air. Examples: nitrogen, carbon dioxide, and methane.

2. Chemical asphyxiants are those materials that prevent the tissues from getting enough oxygen, even though the ambient atmosphere may contain sufficient oxygen. The most common example is carbon

monoxide (a product of incomplete combustion). Carbon monoxide bonds to hemoglobin in the blood 200 times more readily than oxygen. Thus the space for oxygen in blood is utilized by the carbon monoxide therefore preventing the transfer of oxygen to the needy tissues.

b. Irritants - chemicals that have a local effect on the respiratory tract irritate the air passages, often leading to the constriction of these passageways, sometimes edema (liquid in the lungs), and infection. Examples: ammonia and hydrogen fluoride.

c. Necrosis producers - chemicals that cause cell death and edema upon exposure.
Examples: nitrogen dioxide and ozone.

B. Ingestion - The swallowing of a certain chemical can obviously be harmful. Sometimes chemicals are harmful in such small quantities, special precautions must be taken to ensure that they do not inadvertently get into the mouth and swallowed.

1. Effects - two kinds can occur when chemicals are ingested; local or systemic.

a. Local effects in the digestive tract primarily occur when corrosive products are swallowed. Treatment for these problems is often to try to dilute the product rather than to induce vomiting. Examples of these products are hydrochloric acid and sodium hydroxide.

b. Systemic effects can occur from products that are soluble in the fluids of the digestive tract. Once dissolved, the fluids will pass into the blood stream and then be transported to other organ systems of the body.

C. Skin Absorption or Contact.

Upon contact with the skin, chemicals may cause effects that are relatively innocuous, such as redness or mild dermatitis. More serious effects can include destruction of the skin or other debilitating conditions. Many chemicals upon contact with the skin can cause damage to internal organs. Chemicals coming into contact with the eyes can cause local or systemic effects. The eyes are particularly sensitive to many chemicals.

1. Effects - the effects of chemicals that have come in contact with our skin can be either local or systemic.

   a. Local effects may produce various reactions. These chemical can be divided into the three categories.

      (1) Primary irritants: cause irritation on normal skin at the site of contact. Examples: hydrogen chloride, methyl ethyl

ketone (MEK), and toluene.

(2) Photosensitizers: increase the skin's sensitivity to light, resulting in irritation and redness. Examples: creosote, pyridine, and naphtha.

(3) Allergic sensitizers: may produce an allergic type reaction after repeated exposures. Examples: ammonia, chromic acid, and benzoyl peroxide.

b. Systemic effects of chemicals can occur with their absobption through the skin into the blood stream. The ability of the skin to absorb foreign substances depends on; (a) the health and properties of the skin and (b) the chemical properties of the substance. The ability of chemicals to be absorbed through the skin can be enhanced by a number of conditions including but not limited to:

(1) Breaking top layer of the skin
(2) Increasing hydration
(3) Increasing temperature
(4) Increasing blood flow of the skin
(5) Increasing contact time
(6) Concentration of substance
(7) Affected surface area of the skin
(8) Altering skins ph

(9) Decreasing particle size of the substance.

2. Eyes - Generally, chemicals that affect the skin adversely, simularly, effect the eyes which are more sensitive. Such harmful chemicals include.

   a. Acids - Damage to the eyes by acids depends on the ph and the protein combining capacity of the acid. The amount of damage that has occurred by acid burns can be determined in the first few hours, unlike damage from contact with alkali burns.

   b. Alkalies - Like acid burns, alkali burns damage depends on the pH of the chemical. Unlike acid burns, the damage by alkali burn may not be recognized until much later. Damage that initially appears mild could later lead to ulceration, perforation, and clouding of the cornea.

D. Injection - of chemicals can occur by a contaminated object penetrating or puncturing the skin. Effects of the chemicals then occur as the substance is transported to all organ systems of the body by the blood stream.

III. The fate of chemicals after absorption and distribution in the body.

A. Metabolism - The chemical alteration of a substance by the body. Once altered, the resulting products are called metabolites

B. Storage - The chemical or its metabolites are simply stored in the body.

C. Excretion - The removal of a chemical or its metabolite from the body is most commonly via the urine, feces, perspiration, or breath.

Most chemicals share all three of the fates; i.e., some portion of the amount absorbed will be metabolized, another fraction excreted, and a third part stored. Many factors (some understood and some not) influence which portion or percent will be metabolized, stored, or excreted.

IV. Dose Terms

The dose administered of a chemical determines the toxicity of the product. First responders must understand the commonly used terms to describe these amounts.

A. mg/kg - Milligram per kilogram, quantity per unit mass (or weight). This measurement, used commonly for discussing the injection route of exposure, compensates for the different sizes of humans and laboratory animals. First responders must multiply the dose required to get a specific response by the additional weight relationship of humans.

B. mg/cm2 - Milligram per square centimeter - Measures quantity per unit area of skin surface. Used to describe both the amount of the chemical and the amount of skin surface area exposed to that product.

C. PPM - Parts per million - Measurement of vapor or gas per given volume of air. Used to describe the volume of a chemical in air.

D. PPB - Parts per billion - Measurement of vapor or gas per given volume of air. Sometimes certain chemicals produce adverse effects below the one part per million level. In these cases the part per billion level is commonly used.

E. mg/m3 - Milligrams per cubic meter is commonly used measurement of gases in a given volume of air, but also can be used to measure particulates in air.

F. LD50/100 - Lethal dose fifty or one hundred - A calculated dose of a substance which is expected to cause death of 50 or 100 (depending on which level is used) percent of an entire defined experimental animal population. It is from the exposure to the chemical by any route of exposure other than inhalation.

G. LC50/100 - Lethal concentration fifty or one hundred - A calculated concentration of a chemical in air, exposure to which for a specified length of time, is expected to cause the death of 50 or 100 (depending on which level is used) percent of an entire defined experimental animal population.

V. Factors that influence toxicity.

In the decision making process, the first responder must realize that the information gathered concerning a chemical's toxicity is not a constant for all species or even for individuals of the same species. Scientists do not understand all the factors that influence toxicity. No total explanation can be given to describe why one individual can smoke a pack of cigarettes a day the majority of his\her life and live to be 80 years old whereas another individual may develop lung cancer and die at age 45. Even though all the factors are not understood, some are, and must be, considered when making decisions regarding personal health. These factors include:

A. Frequency of Exposure

The frequency of exposure to a chemical is critical to the concentration levels of the toxicant in the body. Toxicant concentrations can gradually increase if sufficient time for the body to rid itself of the chemical between exposures is not present.

B. Duration of Exposure

Duration of exposure as well as frequency of exposure can affect the concentration of a toxicant in the body. The body can rid itself of many toxicants over a period of time. A rapidly received dose of a chemical can produce acute effects from high concentrations of the chemical in the body.

The following definitions reference duration of exposure:

Acute exposure - A single or multiple administration of a chemical within 24 hours or less.

Subchronic exposure - Repeated daily exposure to a chemical for approximately 10% of one's life. (Sometimes the term subacute is used in older references).

Chronic Exposure - Repeated daily exposure to a chemical for approximately 80% of a life span.

C. Route of Exposure

Effects can be different for the same dose of a chemical by simply changing the route it enters the body. Natural barriers can impede the intake and distribution of material once in the body.

D. Interspecies Variation

Differences can occur when exposing different species to the same dose of a chemical. Since the toxicological effects of chemicals on humans are usually based on animal studies, conservatism must be used when using this data in predicting human health effects.

E. Intraspecies Variation

Not all members of a species will react the same to the same dose of a chemical. The differences that can contribute to this in humans include:

1. Age & Maturity

The very young are often more sensitive to toxic interruptions because their bodies systems to handle these interruptions are still in the development stages. The very old are also more sensitive to toxic interruptions because their bodies systems to handle these interruptions have begun to diminish.

2. Gender

The reproductive systems of females can be affected by certain chemicals that pose little risk to the male reproductive system. Since women generally have a larger percentage of body fat than men, women can accumulate more fat-soluble chemicals.

3. State of Health

Individuals with poor health are generally more susceptible to toxic damage because of the body's decreased capability to deal with a chemical exposure.

4. Environmental Factors

Factors such as air pollution, work place conditions, living conditions, personal habits, and previous chemical exposure may contribute to the response for a given chemical.

5. Chemical Combinations

Chemical combinations can produce the same effect that would occur with the exposure to each of them individually, but three other types can occur that must be understood when responding to emergencies where two or more chemicals have been released.

a. Synergists - Chemicals that when combined multiply the effects of one or the other.
b. Potentiation - A type of synergism in which one of the chemicals is generally considered to be nontoxic but in combination with another toxic chemical can increase its toxicity.
c. Antagonists - Chemicals that when combined lessen the effects of each other. Antagonists effects can be either; functional, chemical,

dispositional, or it may act as a receptor.

VI. Summary

Even though the effects of chemicals on humans may vary, using the toxicological data available to responders to formulate response procedures and protective measures is very effective. The most important factors of an incident that must be considered for health effects include; toxicity of the chemical, the amount of chemical, the route of exposure, the species being affected, and the condition of the species being affected (i.e., age, gender, health, and normal environment).

First responders should research the information on the chemical involved, understand its limitations, and make decisions based on this research. A better understanding of the hazards involved enables the responder to make these appropriate response decisions.

EXPOSURE GUIDELINES

I. Introduction

Hazardous materials emergencies present many dangerous situations to both first responders and the general public. One of the most dangerous situations that can be encountered is the exposure to chemicals in high enough concentrations that could present some type of harmful effects. The first responder will have to make vital decisions in the time of crises on acceptable exposures which will affect responders and the general public.

Unfortunately, there is no easy answer for these decisions. The common practice is to use data collected for the protection of workers in areas of known contaminant concentrations and apply it to the emergency situation with some known limitations.

This data is referred to as "Exposure Guidelines." A discussion of this information and its limitations for applying it in the emergency response field follow.

II. Source of Information

Exposure guidelines are generally grouped into two categories; (a) those sources that provide toxicological data and general health guidelines, (b) specific legal exposure limits or recommended exposure guidelines.

Other sources can provide some general guides on chemical exposure such as labels or chemical specific documentation. These sources commonly contain warnings like "AVOID CONTACT" or "AVOID BREATHING VAPORS." Although these warnings give some information about the possible route of exposure and effects, they do not give a safe exposure limit. One may interpret "AVOID BREATHING VAPORS" to mean that even small concentrations could be lethal, or that only high concentrations should be avoided.

III. Ranking Systems

Some sources of information provide relative rankings for chemicals. Their ranking can be very useful but only if the system being utilized is fully understood.

The following are some examples of ranking systems:

A. Dangerous Properties of Industrial Materials, Irving Sax

Assigns terms such as: extremely toxic, highly toxic, moderatly toxic, slightly toxic, practically nontoxic which are based on each chemical's lethal dose 50% (LD^{50}). The following table explains these terms and gives examples for each rating or class.

TOXICITY RATING CHART

IRVING SAX

TOXICITY RATING OR CLASS	**ORAL ACUTE LD_{50} FOR RATS**
Extremely toxic	1 mg/kg or less (dioxin)
Highly toxic	1 to 50 mg/kg (strychnine)
Moderately Toxic	50 to 500 mg/kg (DDT)
Slightly Toxic	0.5 to 5 g/kg (morphine)

Practically Nontoxic	5 to 15 g/kg (ethyl alcohol)

Limitations - The use of LD_{50} information for comparing chemicals presents problems because the LD_{50} is not in direct relation to lower toxicity.

B. National Fire Protection Association (NFPA)

FIRE PROTECTION GUIDE ON HAZARDOUS MATERIALS

This system uses a numbering system (0-4) in the blue section of the NFPA 704 labeling system (discussed in the Identification Section of this manual) to describe toxicity of a chemical. The following table explains the system.

NFPA TOXICITY RATING CHART

(NFPA 704 "BLUE SECTION")

TOXICITY RATING OR CLASS	EXPLANATION & EXAMPLE
0	Nontoxic
1	Slightly toxic
2	Toxic
3	Very toxic
4	Extremely toxic

IV. Research and Regulatory Agencies

For the past 50 years various agencies have been studying exposure limits for the protection of workers. Understanding the different agencies and their rolls can be very confusing. The following explanations will help make the roles of these agencies understandable.

A. Occupational Safety and Health Administration (OSHA) is a Regulatory Agency, having power to enforce guidelines on private industries, federal agencies, and sometimes state and local governments--depending on the state law.

OSHA first published exposure guidelines in 1971 called Permissible Exposure Limits (PELs). These guidelines received a major revision in 1989 since only a few had been updated since 1971. The revised PELs not only changed some of the existing limits but added limits for additional chemicals.

B. National Institute for Occupational Safety and Health (NIOSH)-an agency formed at the same time as OSHA to act as a research organization. Their current duties include making recommendations for new standards and revising old ones as more information is accumulated. The exposure levels NIOSH has developed are called Recommended Exposure Limits (RELs) and have been used in the development of the new OSHA standard. However, not all RELs have been adopted making them PEL's, therefore they are not enforceable standards.

C. American Conference of Governmental Industrial Hygienists (ACGIH) was one of the first groups to develop exposure guidelines. In 1946 they published a list of Maximum Allowable Concentrations (MACs) which was revised and renamed to Threshold Limit Values (TLVs) in the early 1960s. The TLV's are now revised and published yearly.

D. American Industrial Hygiene Association (AIHA) has provided assistance to industries through developing exposure guidelines to chemicals that have not yet been studied by NIOSH or ACGIH. AIHA calls these exposure guidelines Work Place Environmental Exposure Level Guides (WEELs)

V. Types of Exposure Guidelines

While each of the organizations discussed earlier has its own names for exposure guidelines, the types of guidelines they produce are similar in many ways.

A. Threshold Limit Values (TLVs)

1. TLVs are based on the concept that there is a "threshold" dose or concentration below which there are no adverse effects. This is illustrated by the no-effect dose on dose response curves (Figure 1). These limits

refer to airborne concentrations of substances and represent conditions under which it is believed that nearly all workers may be repeatedly exposed day after day without adverse effects.

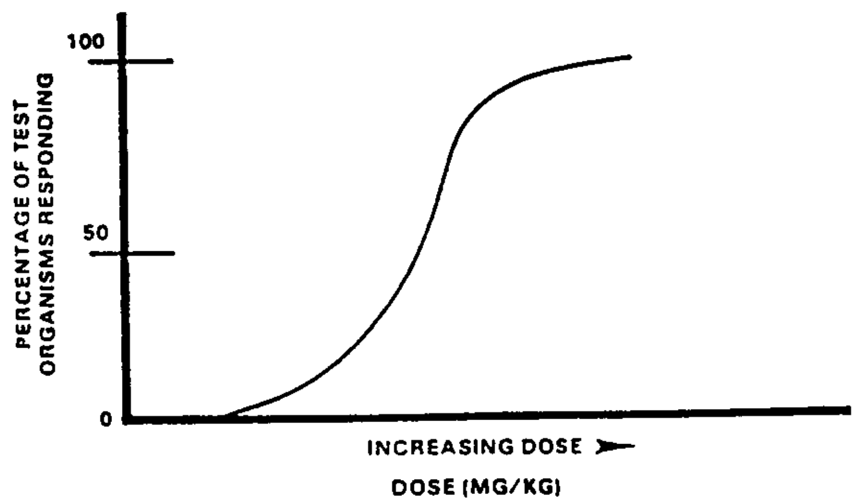


FIGURE 1

2. TLV - Time Weighted Average (TWA)

The TLV - TWA is a time weighted average concentration of a chemical nearly all workers may be exposed to during a normal 8-hour work day and a 40-hour week without showing any toxic effects. This average is determined by averaging the concentrations of the exposure with each concentration weighted based on the duration of exposure. For example an 8-hour exposure would be averaged the following way:

2000 ppm - 4 hours

750 ppm - 3 hours

1000 ppm - 1 hour

$$\frac{(4\text{ hrs})(2000\text{ppm}) + (3\text{ hrs})\ (750\text{ ppm}) + (1\text{ hr})(1000\text{ppm})}{8\text{ hours}}$$

$$= \frac{8000 + 2250 + 1000}{8}$$

$$= \frac{11{,}250}{8}$$

$$= 1406\text{ ppm}$$

This exposure would be compared to an 8-hour TWA exposure limit.

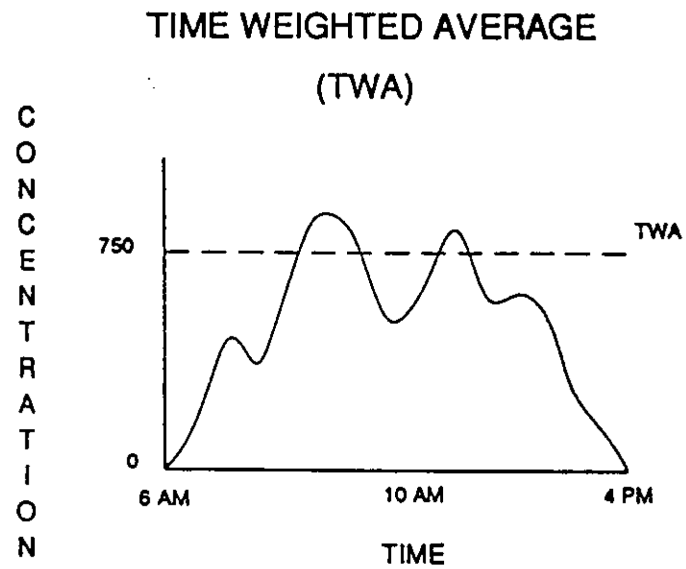


FIGURE 2

OSHAs PELs and NIOSH's REL's are based on the same principles as the TLV-TWA discussed above. They are published only by different organizations.

3. TLV Short Term Exposure Limit (STEL)

Because the 8-hour TWA allows high excursions as long as they are compensated by equal exposures below the TWA limits, another guideline had to be placed to protect workers from acute effects of chemicals. The STEL accomplishes this by allowing exposure to this level for only a 15 minute time weighted average. These excursions must also be 60-minutes apart and should not be repeated more than 4 times a day

Example of exposure compared to a STEL and a TWA.

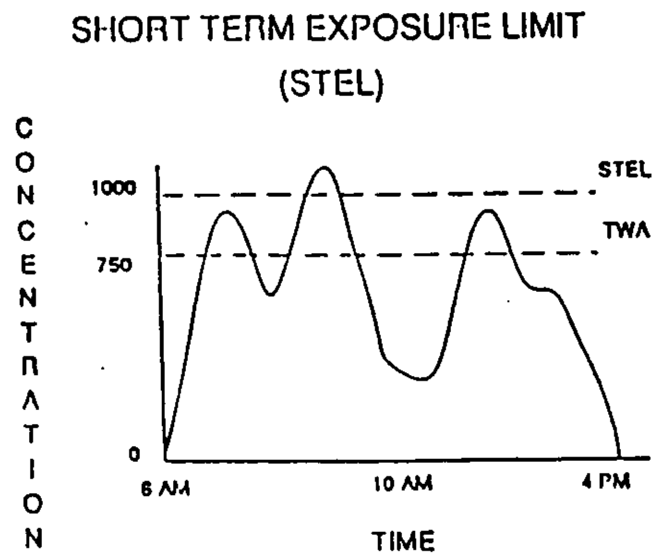


FIGURE 3

3. TLV - Ceiling (C)

Ceiling values exist for substances which result in a rapid and particular type of response. If the chemical of concern has a ceiling level, it should not be exceeded-even instantaneously.

EXAMPLE OF AN ACCEPTABLE
EXPOSURE COMPARED TO CEILING EXPOSURE LIMIT

CEILING
(C)

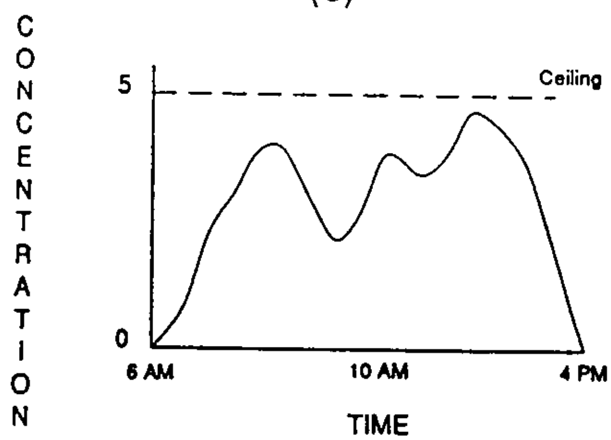


FIGURE 4

B. Immediately Dangerous to Life or Health (IDLH) is defined similarly by OSHA and NIOSH. The definition found in the May, 1987 NIOSH Respirator Decision Logic reads, "a condition that poses a threat of exposure to airborne contaminants when that exposure is likely to cause death or immediate or delayed permanent adverse health effects or prevent escape from such an environment."

IDLH conditions (or the possibility thereof) should automatically dictate the need for respiratory protection to be provided by a positive pressure Self Contained Breathing Apparatus (SCBA) for the first responder.

The use of IDLH information is somewhat limited for the first responder obviously because of the effects at this level. Even though these limitations are present, the data can be useful in assigning a relative toxicity of a particular chemical as compared to other chemicals. The use of other exposure guidelines for this comparison is very limited because they are not based on a specific effect. An example of this limitation would be the comparison of acetone and acrylonitrile based on their TLV-TWA. Based on this exposure guideline acetone appears to be more toxic because its TLV-TWA is lower. But in examining the data, one finds that acetone's TLV-TWA is chosen to prevent irritation to the eyes. The TLV-TWA for acrylonitrile is chosen to reduce the risk of cancer because the IDLH is based on similar health effects, it gives us a better scale of relative toxicity.

V. Mixtures

As discussed in the Principles of Toxicology (section) mixtures of chemicals can greatly increase their toxicity. Because of this, when more than one chemical is dealt with, conservatism must be incorporated when using the exposure guidelines discussed earlier. OSHA recognized this problem and has compensated by providing a formula for employers to use when employees are exposed to more than one chemical. The formula simply allows employees to be exposed to a percentage of the TLV-TWA for each chemical as long as the total percentage of all exposures does not exceed 100%. To compute this exposure, the employer is to use the following formula: $Em=(C_1 \div L, + C_2 \div L_2) + \ldots (Cn \div Ln)$

Where Em is the equivalent exposure for the mixture.
C is the concentration of a particular contaminant.
L is the exposure limit for that substance.

The value of Em shall not exceed one. The following is an illustration of this formula

MATERIAL	ACTUAL CONCENTRATION 8-HOUR EXPOSURE (ppm)	8-HR. TLV-TWA (ppm)
Chemical B	500	1000
Chemical C	45	200
Chemical D	40	200

Substituting in the formula we have:

$$Em = 500 \div 1,000 + 45 \div 200 + 40 \div 200$$
$$Em = 0.500 + 0.225 + 0.200$$
$$Em = 0.925$$

As Em is less than one, this exposure combination is within acceptable limits.

This formula requires detailed information about the specific concentrations for each chemical, in an emergency situation. This formula which provides a basis for requiring additional personnel protective equipment for the first responder when responding to emergencies where two or more chemicals are involved.

CHEMICAL TERMINOLOGY

I. Introduction

On the scene of a hazardous materials emergency responders will be using chemical terminology to describe the hazards of the particular product that is involved. The individual responding to the site must be well versed in these terms in order to function within an assigned role of the incident. The degree which one must understand these terms will depend upon the amount of involvement one has in the emergency. For this reason this section will be divided into three parts, each of which will be assigned a particular level of response. Part one will be for the first responder at an awareness and operational level, parts two and three will contain more technical terms which need to be understood by the Hazardous Material Technician and Hazardous Material Specialist.

II. Terminology for the first responder at an awareness and operations level

1. **Hazardous Materials** - The United States Department of Transportation (DOT) uses the term hazardous materials to cover eight hazard classes, some having subcategories called classifications, and a ninth class covering other regulated materials (ORM). DOT includes in its regulations hazardous substances and hazardous wastes as ORM-E; both are regulated by the Environmental Protection Agency (EPA), if their inherent properties would not otherwise be covered.
2. **Dangerous Goods** - In Canada, they are substances capable of creating harm to people, property, or the environment.
3. **Boiling Point** - the temperature of a liquid when its vapor pressure becomes equal to or slightly higher than that of atmospheric pressure. The temperature at which a liquid will completely turn into a gas.

Example:	Boiling Point
water	212° F

4. **Flammable (Explosive) Limits** - the concentration of a gas that will burn in air.
   a. **Lower Explosive Limit** - (LEL) the lowest percentage of a gas that will burn in air

b. **Upper Explosive Limit** - (UEL) the highest percentage of a gas that will burn in air

Example:	LEL		UEL
Gasoline	1.4%	-	7.6%
Methane	5%	-	15%
Acetylene	2.5%	-	80%

5. **Flash Point** - the temperature at which a liquid or a volatile solid gives off sufficient vapors to form an ignitable mixture above its surface.

Example:	Flash Point
Gasoline	-45° F
Methyl Alcohol	52° F
Diesel Fuel	130° F

6. **Ignition (autoignition) Temperature** - minimum temperature required to initiate or cause self-sustained combustion in a substance; temperature to which the vapors of a product must be heated for ignition to occur.

Example:	Ignition Temp.
Gasoline	536° F
Ethylene Oxide	804° F
Methane	1000° F

7. **Specific Gravity** - the ratio of the density of a liquid or solid to the density of water. Water, being the reference substance, will equal one. Products with a specific gravity less than 1 are lighter than water and those with a specific gravity greater than 1 are heavier than water.

Example:	Specific Gravity
Water	1
Gasoline	0.8
Xylene	0.9
Sulfuric Acid	1.8

8. **Vapor Density** - the ratio of the density of a gas to the density of air. Products with a vapor density less than 1 are lighter than air and those with a vapor density greater than 1 are heavier than air.

Examples:	Vapor density
Air	1
Anhydrous Ammonia	.6
Chlorine	2.5

9. **Vapor Pressure** - the pressure exerted by a vapor when it is in equilibrium with its liquid; a characteristic property of a liquid that tells us the amount of vapor that is to be given off at a certain temperature; usually measured at room temperature (68°F) and given in mm of Hg.

Example:	mmHg at 68° F
Water	17
Ethyl Alcohol	43
Benzene	73

10. **Water Solubility** - the ability of a substance to blend uniformly with water, usually given by simply stating "no" "very slight," "slight," and "yes."

Example:	Water soluble
Gasoline	No
Hydrogen	Slight
Formaldehyde	yes

11. **Alpha Radiation** - a helium nucleus emitted spontaneously from radioactive elements is dissipated in a few centimeters of air or less than .005 mm of aluminum.
12. **Beta Radiation** - a charged particle emitted from a radioactive atomic nucleus. Beta particles are charged, either negative (electrons) or positive (positrons) and travel farther than alpha particles' yet the skin can be protected by a thin sheet of metal from these products.
13. **Gamma Radiation** - an electromagnetic wave with intensely high energy originating in the atomic nucleus . These waves are extremely penetrating and best absorbed by very dense materials such as lead.

III. Terminology for the Hazardous Material Technician

1. **Air Reactivity** - The earth's atmosphere is made up of gases in concentrations that make it very stable. However some products, when in contact with air, undergo a chemical reaction which could generate heat and fire under certain conditions. These materials are also called pyroforic.

   Examples of air reactive products:

   Aluminum Alkyls

   Alkyl Borans

2. **Catalyst** - a substance used to affect (usually speed up) the rate of a chemical reaction but is not used up in the reaction.

Example:	Reaction
Water Vapor	Oxidation of Iron (rust)

3. **Inhibitor** - a compound that retards or stops a chemical chain reaction such as corrosion, oxidation, or polymerization; used quite often to make products with unstable characteristics become stable for use and transportation.

4. **Concentration** - the amount of a given substance in an overall mixture or solution; often used in classification of acids and bases in solution.

5. **Corrosivity** - the ability of a material to attack metals and building materials or cause burns, or irritation to organic tissue, notably the skin.

6. **Critical Temperature** - above this temperature the product cannot be put into a liquid state; no matter how much pressure is exerted on the gas; it must be cooled down to be liquified.

Example:	Critical Temp.	
Oxygen	-146.43° F	> Cryogenics
Nitrogen	-232.78° F	
Propane	206.26° F	

7. **Critical Pressure** - the amount of pressure needed to change a gas into a liquid at its critical temperature; these pressures usually given in atmospheres, (ATM) in which 1 atm = 14.7 psi

8. **Instability** - the characteristic of a compound, mixture, or solution which would allow it to change its form or chemical structure.

9. **Oxidation Ability** - the ability of a material to release oxygen. Materials with a high oxidation ability are known as oxidizing materials. Spontaneously evolve oxygen at, or just above, room temperature. These materials should be stored away from organics because when they come in contact with these materials a violent reaction may occur.

10. **pH (potential Hydrogen)** - a value that will represents the acidity or alkalinity of an aqueous solution; solutions with a pH of 7, are considered to be neutral; acids having a pH less than 7 and bases having a pH

greater than 7. The farther away from 7 on the 0-14 scale, the stronger the acid or base. This scale does not determine concentration of the solution therefore more information is needed to make appropriate response decisions.

11. **Polymerization** - a chemical reaction usually carried out with a catalyst, heat or light, and often under high pressure, in which a large number of simple molecules combine to form a much larger chain-like macromolecule.
12. **Radioactivity** - the amount of ionizing radiation emitted spontaneously by a material. Generally one of three basic forms: alpha, beta, (both of which are a particulate) or gamma, (which is an electromagnetic wave) which is the most dangerous from an exposure standpoint because of the difficulty of protecting oneself from.
13. **Self Accelerating Decomposition Temperature (SADT)** - temperature at which decomposition of a molecule becomes self-feeding and irreversible; upon reaching that temperature, a material decomposes with explosive force.
14. **Strength** - level of reaction of a particular acid or base; acids in the pH 1-2 range are thought to be strong acids while bases in the 13-14 pH range are strong bases. This term does not define the amount of acid or base in solution just the particular level of reaction therefore the terms strong and concentrated are in no way synonymous.

15. **Sublimation** - direct passage of a substance from the solid state directly to the vapor state without passing through the liquid state.

    Examples of products capable of sublimation:

    Carbon Dioxide

    Moth balls

16. **Surface Tension** - inward pull or internal pressure of a liquid that tends to restrain the liquid from flowing; low surface tensions tend to flow readily (Example: benzene); high surface tensions do not flow so well, if at all (Example: mercury).

17. **Viscosity** - internal resistance to flow of a product (often used to define thickness of a liquid or sludge).

    Examples:

    Water: a viscosity of .01002 poise

    Hexane: less than .01002 poise (a thin liquid)

    Molasses: much greater than .01002 poise (a very thick liquid)

18. **Volatility** - tendency of a liquid or solid to pass into the vapor state. Volatile liquids readily give off vapors and have low boiling points (Example: hexane). Nonvolatile liquids give off little or no vapors at room temperature (Example: polychlorinatedbiphenyls (PCBs).

19. **Water Reactivity** - the materials ability to react with water. Water reactive materials react with water or humid air causing some type of release in the form of heat, fire or the generation of some type of gas.

20. **Hazardous Substances** - EPA uses the term hazardous substance for chemicals which, if released into the environment above a certain amount, must be reported; depending on the threat to the environment, federal involvement in handling the incident can be authorized.

21. **Extremely Hazardous Substance** - EPA uses the term extremely hazardous substance for chemicals which must be reported to the appropriate authorities if released above the threshold reporting quantity; each subtance has a threshold reporting quantity.

22. **Hazardous Waste** - EPA uses the term hazardous waste for chemicals that are regulated under the Resource, Conservation Act (40 CFR Part 261.33). Hazardous wastes in transportation are regulated by DOT (49 CFR Parts 170-179).

23. **Hazardous Chemicals** - The United States Occupational Safety and Health Administration (OSHA) uses the term hazardous chemical to denote any chemical that would be a risk to employees if exposed in the work place. Hazardous chemicals cover a broader group of chemicals than the other chemical lists.

IV. Terminology for the Hazardous Material Specialist

1. **Compound** - a substance made up of atoms of two or more elements which are chemically bonded together. These elements have definite proportions by weight and are represented by a chemical formula.

   Example:

Compound	Chemical Formula
Water	H_2O
Methane	CH_4

2. **Mixture** - a substance which is made up of different elements but cannot be represented by a chemical formula. Its components can usually be separated by mechanical means.

   Example:

   Air
   Gasoline
   Plastics
   Sea Water

3. **Halogenated Hydrocarbon** - a (hydrocarbon) such as methane, benzene, or ethylene in which one or more of the hydrogen atoms have been replaced with one of the halogen family elements (fluorine, chlorine, bromine, iodine, astatine).

   Example:

   Methane Ch_4 -> Carbon Tetrachloride CCl_4
   Benzene C_6H_6 -> Chlorobenzene C_6H_5Cl

4. **Ionic Bond** - a chemical bond in which electrons are transferred from one element to another creating a cation and an anion which are held together by an electrostatic charge; metals and nonmetals bond in this fashion creating salts.

5. **Covalent Bond** - a chemical bond in which electrons are localized and shared between atoms rather than transferring from one to another. Such bonds used by nonmetals bonding together form nonsalts.

6. **Salt** - compound formed when a metal and nonmetal ionically bond together; the neutralization process of acids and bases forms water and a salt.

7. **Nonsalt** - the compound formed when a nonmetal and another nonmetal chemically bond together using a covalent bond.

8. **Saturated Hydrocarbons** - a hydrocarbon, in the state in which all available valence bonds are attached to hydrogen atoms rather than combining with themselves with double, triple, or resonant bonds.

Example:	Formula
Methane	CH_4
Ethane	C_2H_6
Propane	C_3H_8
Butane	C_4H_{10}

9. **Unsaturated Hydrocarbons** - a hydrocarbon in which all valence bonds are not taken up by hydrogen atoms and the carbons bond with themselves with double or triple bonds.

(These materials are more unstable than the saturated hydrocarbons and quite often pose a greater risk of fire or explosion to the responder). Example: ethylene C_2H_4, Acetylene C_2H_2.

10. **Aromatics** - hydrocarbons containing at least one 6 carbon ring with three double (resonant) bonds. (The most prevalent of these compounds is benzene which contains one 6 carbon ring with 6 hydrogen atoms attached to it. They have a characteristic odor and are generally thought of as being more toxic than typical saturated or unsaturated hydrocarbons).

    Example:

    Benzene

    Styrene

    Xylene

11. **Solution** - a mixture containing one or more substances dissolved (the solute) into one or more substances (the solvent)

    Example:

    Alcohol & Water

    Salt & Water

12. **Slurry** - a thin watery solution with solids suspended in it. (Some blasting agents are considered slurries, such as gelatinized aqueous ammonium nitrate compounds).

13. **Water Miscible** - the ability of a substance to dissolve in water without separating into two phases.

Example of miscible substances:

	Miscibility
Water & Alcohol	Complete
Carbon Dioxide & Water	Partially
Water & Oil	Immiscible (do not mix)

14. **Half-life** - a term used to describe a radioactive material which is the time required for a material to disintegrate to half its original mass. (This time can range from seconds to hundreds of years).

15. **Time, Distance, Shielding** - gamma rays, the most dangerous type of radiation and the most difficult to protect oneself from. The only way is through time, (shorten the exposure), distance (increase the distance between the source and the person), and shielding or mass (increase the mass between the source and person i.e., lead or earth).

INFORMATION RESOURCES

I. Introduction

A great deal of information is required when responding to hazardous materials incidents. The information needed includes (a) physical and chemical properties of the material, (b) site or surrounding area information, (c) possible treatment and protection methods to be used at the emergency. This information should be compiled from several different resources: Material Safety Data Sheets (MSDS), reference guidebooks, Hazardous Materials databases, technical information centers, technical information specialists, and monitoring equipment. With the large amounts of information needed and the wide range of resources available, the responder must be able to prioritize the information. Resource materials may give different points of view. A responder should never depend on one resource, yet, too many references can become overwhelming and confusing. This section will list some of the references available to the responder and give a sample data sheet that can be filled out during the onset of an emergency to help with initial decisions that need to be made.

II. Reference Manuals

A. Emergency Response Manuals

1. <u>DOT Emergency Response Guidebook (ERG)</u>
U.S. Department of Transportation
Copies available through J.J. Keller & Associates
1-800-558-5011

ERG, probably the most used reference book by policemen and firemen, contains 3 main sections.

1. The first section (yellow pages) lists chemicals in order of their United Nations (UN), Identification (ID) numbers, found on D.O.T. placards. Next to the number, is the chemical name and a guide number to follow in the third section of the book.

2. The second section (blue pages) is a listing of chemicals in alphabetical order with their corresponding UN/ID numbers and a guide number for procedures to follow.

3. The third section (white with orange stripe on top) is made up of 76 different guides (1987 Edition) to follow in the event of an emergency dealing with one of the chemicals listed in the first two sections.

In the back of the book is a table of evacuation distances for a limited number of chemicals. A diagram of the different placards with the proper guides to follow is also shown in case the placard is all that is available to the responder.

The Emergency Response Guidebook is a good reference for some initial decisions that need to be made immediately at the scene of an emergency. It is very generic in its approach to handling the specific chemicals involved. Before offensive actions are to be taken, a more specific reference should be used to confirm information in the DOT Guidebook.

2. Emergency Handling of Hazardous Materials In Surface Transportation

Association of American Railroads/Bureau of Explosives
1920 L.Street, N.W. Wash., D.C. 20036

This reference contains specific information on over 2,400 chemicals covering all substances listed by the Environmental Protection Agency (EPA) as hazardous substances and all substances listed in Title 49 of the Code of Federal Regulations as hazardous materials. The back is a cross reference of chemicals listed by their DOT UN/ID numbers, also their STCC (Standard Transportation Commodity Code) number which is used in rail transportation. A description of the material, emergency actions to be taken, personnel protection procedures, along with evacuation and environmental considerations for each of the products listed. It is quite often called a standard for references for the emergency responder.

3. <u>Emergency Action Guides</u>
American Association of Railroads
1920 L.Street N.W. Wash.,D.C. 20036

The <u>Emergency Action Guides</u> (EAG) provides information for over 130 chemicals which make up over 95% percent of the hazardous materials by volume carried by rail. Physical and chemical properties of the materials are listed, also some actions to be taken in the event of a spill or fire. Consequences of these actions are also listed in the guides to help the responder in all phases of the incident.

4. <u>Chemical Hazard Response Information System (CHRIS)</u>
U.S. Coast Guard, Wash.D.C.
Commandant Instruction M. 16565.12A

The CHRIS manual was developed for the Coast Guard in response to spills on or near waterways. This manual has specific chemical, physical, and biological information on over 1000 chemicals. Even though it was developed for spills on the waterways and is quite bulky, it provides the responder reliable information and knowledgeable procedures in a style and manner clearly read and understandable.

5. <u>NFPA Fire Protection Guide on Hazardous Materials (NFPA)</u> Batteryman L. Park, Quinch, Massachusetts

   This manual is broken into four (4) main parts: (1) Properties of flammable liquids, gases, and solids; fire hazards of 1300 products. (2) Data on fire, explosion and toxicity hazards of over 400 chemicals and includes other properties of materials that need to be considered other than fire hazards, mainly toxicity. (3) The third section gives information on the results of mixing certain materials, covering 3500 chemicals and their possible hazardous reactions if they come in contact with other chemicals. A specific chemical is listed followed by a list of chemicals that would cause a hazardous reaction. (4) A detailed explanation of the NFPA 704 labeling system with an explanation of each of the ratings in its respective class of fire, health, reactivity or special hazards.

B. Reference materials found in the workplace that are useful to the first responder

1. <u>Condensed Chemical Dictionary</u>
   Van Nostrand Rienhold Company
   135 W. 50th St., NY, NY 10020

This dictionary gives a brief definition of thousands of chemicals along with technical and descriptive information, defining many of the terms used in the chemical industry that to describe these materials and their behaviors.

2. Dangerous Properties of Industrial Materials (Sax Manual)
Van Nostrand Reinhold, Co. 135 W. 50th St., NY, NY 10020

Provides detailed technical information on over 13,000 materials found in the work place. Some type of chemistry background will help the readers in interpreting this data.

3. NIOSH Pocket Guide to Chemical Hazards

Presents information on 398 individual chemicals or chemical types (e.g., cyanides, copper dust, and mists) found in the workplace including chemical incompatibilities, is designed to be used as a quick reference source; relates to general industrial hygiene and medical surveillance practices for the protection of workers. This information must be adapted by the responder for emergency response procedures.

4. Documentation of the Threshold Limit Values (TLV)
ACGIH Publication Office 6500 Glenway Av. Bldg. D-5, Cincinnati, OH 45221

The TLV Booklet, as it is commonly called, provides exposure guidelines for workers around hazardous substances. This material is helpful to the responder, but a good understanding of TLV's is needed to use this reference properly.

5. <u>Farm Chemicals Handbook</u>
Meister Publishing Co., 37841 Euclid Av., Willoughby, OH 44094

Though not designed for the emergency responder, this manual contains information that is very difficult to locate in other resources. It is designed for use by those in the farming industry; contains advertisements and buyers guides for different products used in the industry. The main section of the manual contains information on farm chemicals (pesticides, etc.). This is helpful if the responder has the basic chemical knowledge to interpret the data. Trade names are listed which is often all that a responder has available at a spill. By listing chemicals this way, pertinent information can be found with relative ease. Information such as chemical name, toxicity levels, signal word (caution, warning, danger), protective clothing,

handling procedures along with the names of the manufacturers are listed on each of the chemicals.

6. The Merck Index
Merck and Co., Inc., Rahway, NJ 07065

This book is considered an encyclopedia of chemicals, drugs, and biological substances. It provides a substantial amount of information and has an extensive index and cross index to make it easier to use. Like the SAX manual, the Merck index is difficult to understand unless the user has some chemistry background.

7. Handbook of Reactive Chemical Hazards
by L. Bretherick published by Butterworths, Boston, MA

The main purpose of this reference is to present information on the instability of specific chemicals; supplemented with sections on hazardous interactions of chemicals. Though it may be difficult for some responders to understand the chemical terminology this reference furnishes pertinent information on chemical reactions.

C. Textbooks written about the Hazardous Materials Field

Though these books may not provide specific information on the scene of an emergency, they have a great deal of information needed to properly respond to these emergencies.

1. Hazardous Materials for First Responders
International Fire Service Training Association (IFSTA) Published by Oklahoma State University

2. <u>Hazardous Materials</u>
by Warren Isman and Gene Carlson

3. <u>Hazardous Materials/Waste Handling for the Emergency Responder</u> by kenneth J. York and Gerald L. Grey

4. <u>The Common Sence Approach to Hazardous Materials</u> by Frank L. Fire

5. <u>Chemistry of Hazardous Materials by Eugene Meyer</u>

D. Computer Programs for Hazardous Materials Responders

1. <u>Computer Aided Management of Emergency Operations</u> (CAMEO)

This program is designed to assist the responder with specific data on over 2400 chemicals and will also search for chemicals using their synonyms, I.D. number, NOAA number, STCC number, or CAS number. At fixed site facilities, the synonyms are used and the proper chemical name may not be know. Cost of this program is very low and is the most used program by responders; program is now available in Macantosh and IBM compatible versions.

2. <u>Atropos</u> by Dart Software

This program provides information on chemicals similar to the <u>Emergency Response Guidebook</u>, also information on the potential hazards when chemicals are mixed, is presented.

3. Automated Resource for Chemical Hazard Incident Evaluation (ARCHIE)

This program provides information helpful in planning for hazardous material emergencies by giving air dispersions of chemicals when released into the atmosphere. It is also helpful in determining hazard zones in the event of an explosion of flammable materials.

4. Chemtrec (Hazardous Information Transmission) HIT system

The HIT system is sponsored by Chemtrec. Callers can receive a hard copy of information on specific chemicals in the event of an emergency. The program requires that the response personnel be preregistered in the program and have a modem and printer to receive this information.

5. Chemtox

This is a database containing over 3500 chemicals with specific chemical, physical and toxicological data on each. It also contains a section which will give material incompatibilities which is helpful if mixing of materials were to occur.

F. Technical Assistance Centers

1. Chemtrec (Chemical Transportation Emergency Center)

The Chemical Manufactories Association (CMA) developed Chemtrec to provide assistance to responders on the scene of a Hazardous Materials emergency. It can be contacted by telephoning 1-800-424-9300 24 hours a day. Chemical information along with manufacturers of chemicals are available to the responder. Chemtrec also has an industry wide mutual aid response system called Chemnet, that will respond to the site of an emergency if needed. When contacting Chemtrec the following information should be provided.

- Callers name and agency
- Call back number
- Chemical(s) involved (spelled out)
- Shipper
- Manufacturer
- Incident specifics

2. CHLOREP (Chlorine Emergency Plan) Access through Chemtrec

The Chlorine Institute developed this system of manufactures to assist the responder in the event of a chlorine emergency. Each participating manufacturer has trained personnel to respond in their area or provide assistance over the phone to responders.

3. National Response Center - 1-800-424-8801

This center is useful in getting assistance from the Environmental Protection Agency (EPA) or the Coast Guard. It is also the center that must be called by the spiller in the event of a spill of a reportable quantity of hazardous products.

4. Bureau of Explosives/American Association of Railroads, (202) 835-9500

This is a 24 hour number provided to responders to help in the event of a railroad emergency. It can also be contacted through Chemtrec.

G. Material Safety Data Sheets

Materials Safety Data Sheets (MSDS) are required on hazardous substances by the OSHA Hazard Communications Standard 1910.1200. MSDS are a product specific information system which furnishes more comprehensive information on its particular chemical than any of the references discussed earlier. The MSDS should always be used if possible by the responder for emergency procedures.

There is no standard format for MSDS(s) but they are required to provide specific information to meet requirements of the law. Such as:

1. Chemical & common names of ingredients
2. Exposure limits
3. Information on carcinogen listings
4. Fire and explosion potential
5. Health effects
6. Routes of exposure
7. Physical and chemical characteristics
8. Signs and symptoms of exposure
9. Precautions for handling and use
10. Personnel protective equipment for handling
11. Emergency procedure for spills and fires
12. Disposal procedures
13. First aid procedures
14. Date of last update of sheet
15. Name, address, and phone number of person providing the information

MSDS is one of the best sources of information available to the responder; however, they are also limitations. The main limitation is that trade secrets quite often do not have to be revealed on a MSDS. This may be needed information that must be obtained from another source.

III. Information Gathering

On the scene of a Hazardous Materials emergency, at least one person should be designated to gather information on the products involved. This person must be able to pick out the proper resources needed along with what information is needed from each. This is not an easy task; therefore, it is helpful to have a data collection chart set up prior to the emergency. The chart should be filled out on the specific chemical with all the pertinent information. The following pages are an example that can be used in an emergency.

DATA COLLECTION TABLE

RAIL ROAD

I. PHYSICAL/CHEMICAL PROPERTIES	CONDENSED CHEMICAL CCD DICTIONARY	SAX	CHRIS	NIOSH POCKET	CAMEO	EMERGENCY ACTION GUIDES	OHMTADS	M.S.D.S
Physical state				COLORLESS GAS OR LIQUID (FLAMMABLE GASS)			FLAMMABLE GAS	[illegible]
Molecular weight				62.5				62.35
VAPOR (water=1) Density/specific gravity				7				~~[illegible]~~ .912
Boiling point								7.0°F
Melting point				-256°F				-302°F
Vapor pressure @ temp.				71 ATMO.				2580 @ 68°F
(in air)=1 Vapor specific gravity								~~[illegible]~~ 2.15
Flash point (oc/cc)								-108°F
Autoignition point								882°F
LEL/UEL				3.6/33%				4/22%
Solubility (water)				.1%				1.1MG/L
Soulbility (other)								
I.P.				9.99				
TLV								5.0 PPM
IDLH								
Odor threshold								

Synonyms / Uses:

DATA COLLECTION TABLE (cont'd)

HAZARDOUS CHARACTERISTICS (Include Source)

A. TOXICOLOGICAL

1. Inhalation: ______________________________

____

____

2. Ingestion: ______________________________

____

____

3. Eye/Skin contact: ______________________________

____

____

4. Aquatic ______________________________

____

____

B. COMBUSTION:

1. Flammability/Explosiveness: ______________________________

____

____

2. Extinguishment ______________________________

____

____

C. REACTIVITY

1. Incompatibilities ____________________

____

____

2. Reaction Products ____________________

____

____

3. Chemical treatment methods ____________________

____

____

4. Other ____________________

____

D. PROTECTIVE CLOTHING: ____________________

____

____

1. Public ____________________

____

____

2. Environment ____________________

____

____

F. NFPA RATINGS:

1. Red (flammability) ____________________

2. Blue (health) ____________________

3. Yellow (reactivity) ____________________

G. HAZARD PLACARD ____________________

THE INCIDENT COMMAND SYSTEM

I. Introduction

Because each hazardous materials incident is unique, the number of responding personnel may vary from one or two people to hundreds of people encompassing numerous agencies. The materials involved, their effects, as well as the operations required to prevent or reduce the effects of the release, are specific to each incident. However, there is one step we can take prior to the actual incident in order to utilize our resources to maximum capabilities. The components--preplanning, organizing, locating resources (personnel, equipment, and funds), training, and implementing response operations constitute an organized, written plan known as an - Incident Command System.

II. History of Incident Command System

There are several different systems being used today. The National Fire Academy has adopted the Incident Command System (ICS) which was developed in the early 1970s a result of a series of major wild fires in southern California. These major fires crossed jurisdictional boundaries and caused municipal, county, state, and federal fire authorities to form an organization known as Firefighting Resources of California Organized for Potential Emergencies (FIRESCOPE). The organization identified some difficulties which directly affected the efficiency of their groups. The difficulties were organizing multiagency efforts, ineffective communications, lack of accountability, and lack of a well defined command structure. Their efforts to overcome these obstacles resulted in the development of the original incident command system for effective incident management.

III. Elements of Effective Incident Management System

In order to be effective, an incident management system must be suitable for use regardless of the type of jurisdiction or agency(s) involved. These may include single jurisdiction/single agency, single jurisdiction/multi agency, or multi jurisdiction/multi agency involvement. The organizational structure must be adaptable to any incident and acceptable to users throughout a community or region. It must be readily adaptable to new technology and capable of logical expansion from the initial response to the complexities of a major emergency. For maximum efficiency of a system, three common elements are necessary: organizational structure, terminology, and procedures. This ensures the ability to quickly and effectively move resources committed to the incident with the least disruption to existing systems. This must be in place prior to an incident by writing a contingency plan for emergency response.

IV. Contingency Plan for Emergency Response

During an incident, people attempt to control and alleviate the situation, some sort of organization will evolve. Without a prewritten community emergency contingency plan, the ability to effectively manage any crisis is diminished. The critical time of a hazardous materials incident--the first few minutes--is usually spent in chaos. Time is wasted defining the problem, organizing personnel, locating resources, and then taking action. By having a written contingency plan in place we can overcome these problems.

A contingency plan anticipates the many problems involved in a response and through planning develops solutions in advance. A response organization is developed and resources are identified. Notification systems are in place as well as procedures for locating technical and other kinds of assistance. Once activated, the plan can rapidly begin to function with fewer delays. A preexisting plan also reduces the risk to both responder and the public by establishing in advance, procedures for protecting their health and safety.

In order that a plan be functional, it must be tested. The plan cannot anticipate and address all problems involved in the release of chemicals. Modifications will be needed to accommodate unforseen events. A well-written plan acknowledges that incident specific adaptations are necessary and are written to provide flexibility.

To be effective, the contingency plan (like a site safety plan) must be:

- Well - written
- Flexible
- Continuously reviewed and changed
- Agreed upon by all involved
- Frequently tested
- Current.

V. Organizing The Response Effort

Hazardous materials response plans exist at all levels of government--local, state, and federal. A response may involve hundreds of people from numerous organizations, ranging from local government to private industry. A contingency plan establishes the response organization and provides operational procedures. It contains provisions for incorporating all agencies into the response effort as well as their roles, responsibilities, and relationship. To function efficiently, the organization which is established must:

- Provide a leader
- Establish authority
- Develop policy and procedures
- Determine objectives
- Assign responsibilities
- Manage resources (money, equipment and personnel)
- Plan and direct operations

- Establish internal communications
- Establish communication with outside organizations.

This organization, the Incident Command System, must have a defined structure of the relationship between the various components of the organization. The chain of command and established internal communication channels must be set. The form and complexity of the organization chart depend on the magnitude of the incident. The key requirements of an organization are:

- Defining a chain-of-command
- Assigning responsibilities and functions
- Specifying personnel requirements
- Establishing internal communications

VI. Key Personnel and Their Functions

Key personnel and their functions, usually specified in the response plan, make up the response team. The positions, functions, and responsibilities at incidents vary. Key personnel and the functions they execute should be tailored to meet the needs of a particular hazardous materials incident.

Key personnel and functions that may be needed are:

INCIDENT COMMANDER, ON-SCENE-COORDINATOR OR INCIDENT MANAGER: Has clearly defined authority and responsibility to manage and direct all response operations.

SCIENCE OFFICER: Directs and coordinates scientific studies, sample collection, field monitoring, analysis of samples and interpretation of results. Recommends remedial actions. Provides technical guidance to the Incident Commander in those areas.

SAFETY OFFICER: Advises the Incident Commander on all matters related to the health and safety of those involved in emergency operations. Establishes and directs the safety program. May halt operations if unsafe conditions exist. Coordinates activities with the Science Officer.

FIELD LEADER: Directs activities related to cleanup contractors and others involved in emergency and long term restoration measures.

PUBLIC INFORMATION OFFICER: Releases information to news media and the public concerning response activities.

SECURITY OFFICER: Manages the site's physical security. Provides liaison for local law enforcement and fire departments controls site access.

RECORD KEEPER: Maintains official record of site activities. Assumes proper completion of required reports.

OPERATIONS OFFICER: Directs activities of team leaders. Coordinates these activities with the scientific advisor and safety officer.

SECTOR LEADERS: Manage specific assigned tasks such as:

- entry team(s) - decontamination - sampling - monitoring
- equipment - photography - communications

FINANCIAL OFFICER: Provides financial and contractual support.

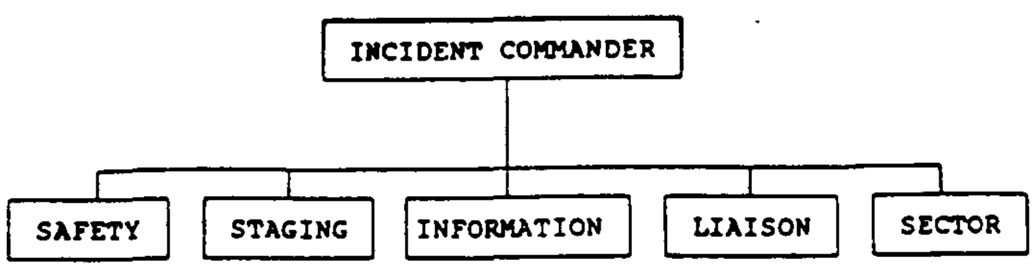
LOGISTICS OFFICER: Provides necessary equipment and other resources.

MEDICAL OFFICER: Provides medical support. Acts as liaison with the medical community.

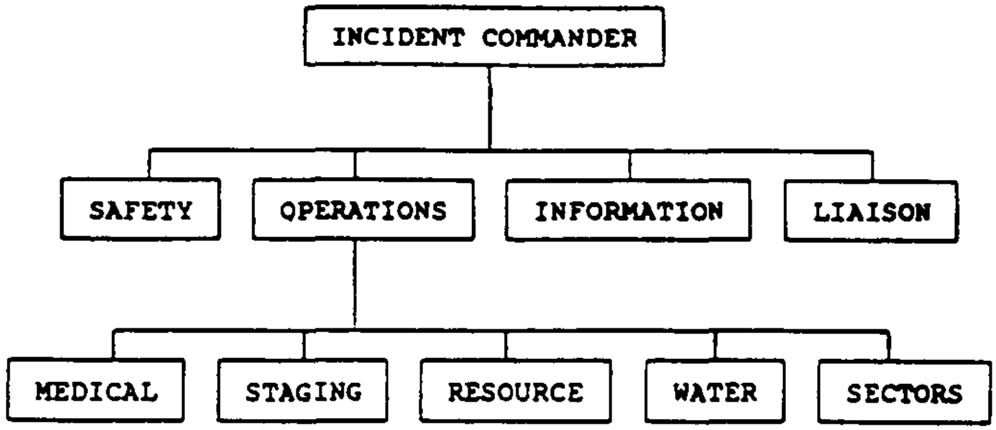
VII. The Incident Command System.

The Incident Command System (ICS) should automatically be activated when an incident occurs. The ICS designates who is-in-charge (Incident Commander), establishes a chain-of-command, and lists key personnel and their functions. The first arriving officer is the incident commander and remains so throughout the incident unless succeeded by a higher ranking officer. To transfer command, the present incident Commander must verbally update information and actually pass the command to the new I.C.

A major incident requires a larger response force with individuals performing many specialized functions. Smaller incidents require fewer responders and activities. The ICS is designed to be flexible enough to permit the Incident commander to adapt it to any situation and still maintain management control over responding personnel. The size and complexity of the organization needed are dictated by the magnitude of the particular incident.



COMMAND STRUCTURE FOR A SMALL RESPONSE



COMMAND STRUCTURE FOR A MAJOR RESPONSE

In most jurisdictions, the fire service is in charge of a hazardous materials incident. It may have a dedicated hazardous material response team (HMRT), but usually the HMRT has more than one function. Depending on the incident, the HMRT may be the only fire service unit responding. In this situation the team commander becomes the Incident Commander (IC).

VIII. Implementing Response Operations

The release or potential release of a hazardous material requires operations that will eventually restore the situation as near as possible to pre-incident conditions. Although each incident establishes its own operational requirements, there is a general sequence of response operations common to all responses.

Planning and implementing a response, as a minimum, requires the responders to:

<u>ORGANIZE</u>: Establish an organization. Select key personnel. Assign responsibilities. Modify as operations proceed.

<u>EVALUATE THE SITUATION</u>: Based on available information, make preliminary hazard evaluation. Determine impact of incident with or without intervention.

<u>DEVELOP A PLAN OF ACTION</u>: Develop preliminary operations plan for collecting information, implementing immediate countermeasures and rescue operations and instituting emergency actions. Continually re-evaluate the situation as supplemental information becomes available.

<u>MAKE PRELIMINARY OFF-SITE SURVEYS</u>: Collect additional data to evaluate situation (use direct reading instruments, collect sample, make visual observations). Institute emergency actions to protect public health and the environment. Identify requirements for on-site reconnaissance. Determine Level of Protection if necessary, for off-site personnel. Establish boundaries for contaminated areas.

<u>MAKE INITIAL ON-SITE RECONNAISSANCES</u>: Collect data (use direct-reading instruments, collect samples, make visual observations) to determine or verify hazardous conditions and make an overall assessment of the incident. Modify initial entry safety procedures as more data is obtained. Determine levels of protection for initial entry team(s) and subsequent operations. Plan and implement site control and decontamination procedures.

<u>MODIFY ORIGINAL PLAN OF ACTION</u>: Modify or adapt original plan based on additional information obtained during initial entries. Revise immediate emergency measures. Plan long-term actions including:

- Additional monitoring and sampling
- Resource requirements
- Legal implications and litigation
- Cleanup and restoration measures
- Site safety plan
- Site activity documentation

Of paramount importance in any response is the safety and health of the responders. Their risk increases as they get closer to the hazardous materials. Operations on-site, must be carefully planned and executed. Before entering the immediate area of a release or potential release, as much information as possible should be collected; for example, shipping papers, transportation placards, existing records, container labels, and other visual observations (in the time available) concerning the types and degree of hazards and risks which may exist. Available information is used to determine:

- Whether off-site measures are needed
- The need to go on-site
- The types of equipment available
- What data is needed to evaluate hazards:
    - organic vapors/gases
    - inorganic vapors/gases
    - particulates
    - oxygen concentration
    - radiation
    - samples needed for laboratory analysis
- Levels of protection entry team(s) need
- Equipment needed
- Number and size of entry team(s)
- Frequency of briefings for the response team
- Need for site control procedures including:

designation of work zones

access control

physical barriers

- Which decontamination procedures are required (Should be in place prior to entry)
- Need for having backup medical resources
- Taking emergency actions/countermeasures
- Priority for collecting data and samples

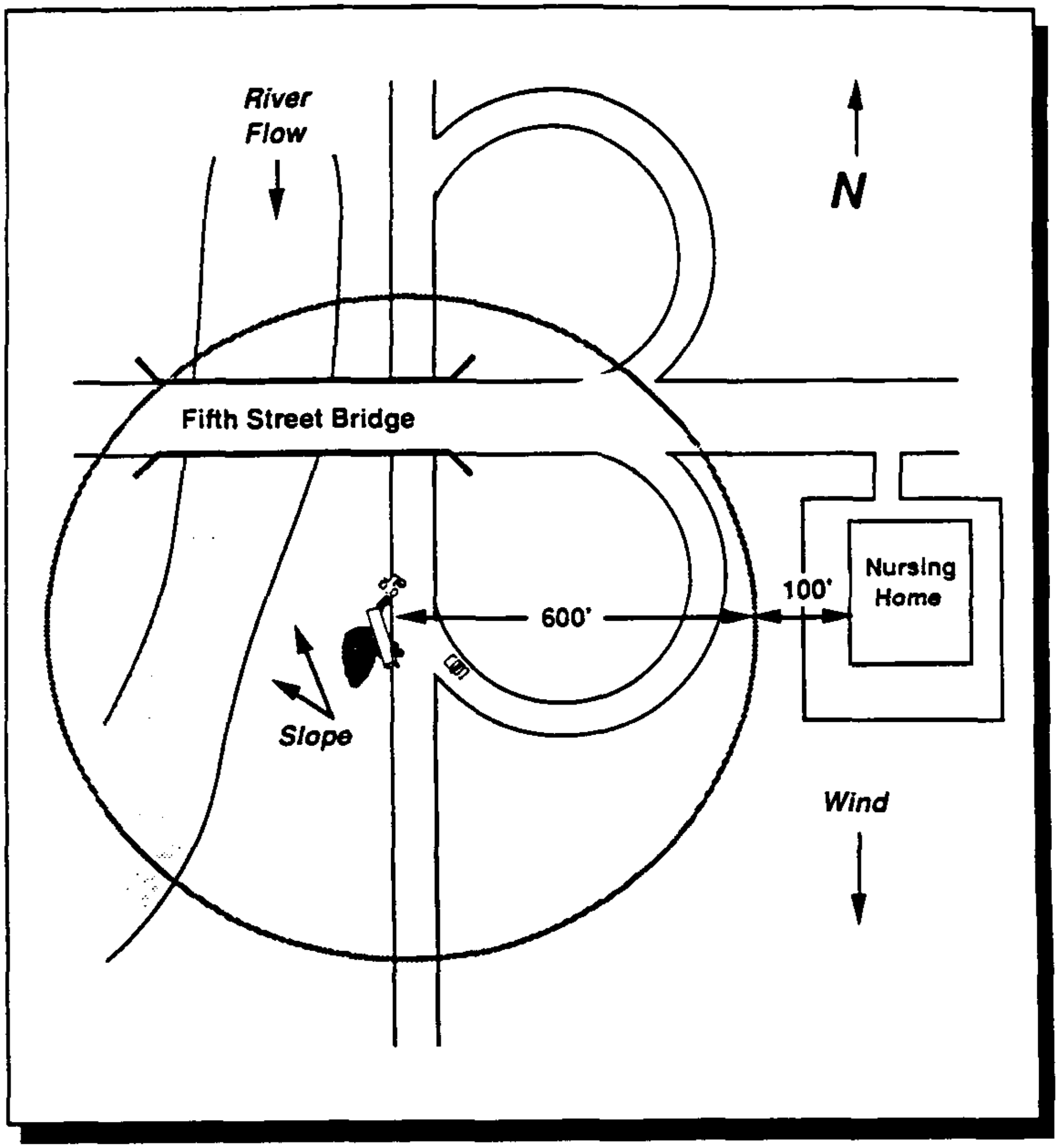
XI. Termination Procedures

An incident may be "scaled down," which allows the incident commander to release unneeded personnel. He should have the section officers prepare inventory list of all tools, equipment, materials and funds used. These items should be thoroughly checked, cleaned, repaired or replaced and put back in service as soon as possible. The IC should update the emergency response plan and communicate the change to all involved. The Incident Commander must be sure the environment is as near to pre-incident condition as possible and be prepared for the next incident.

X. Summary

To effectively prevent or reduce the impact of a hazardous materials incident on people or the environment, the personnel responding must be organized into a structured operating unit--a response organization. In order to maximize its efforts, the organization must be developed in advance, written down, be tested and become an integral part of a hazardous materials contingency plan. The success of the response is dependent upon how well the response personnel ar organized. The better organized, the quicker the response team can begin to function. However the organization must be flexible enough to adapt to the changing conditions created as the incident progresses. The incident command organizational structure develops in modular fashion from the top down. The five functional areas which are implemented as the need develops are: command (always established), operations, logistics, planning, and finance.

Hazardous Materials Incident-Acrolein Spill



STUDENT DIRECTIONS

1. Your group will be assigned one (1) of the following functions:

Command	Command Staff
Operations	Planning
Logistics	Finance

2. Select an individual to participate in a meeting of the IC, Command, Staff, and General Staff. The balance of the group will serve as support personnel.

3. The individuals selected by each group as IC, Command Staff, and General Staff will report to the front of the classroom for briefing.

   In this briefing, the IC, Command Staff, and General Staff will determine the general strategy and initial actions that each of the staff officers needs to begin to develop. **Maximum time limit 12 minutes.**

   The information provided in this scenario is limited, and is not completely sufficient to make detailed tactical decisions. The establishment of strategy and a preliminary action plan delineating tactics is based on the assumption that the hazardous materials team is available and has the appropriate technical expertise and resources for the incident.

   The Department of Transportation Emergency Response Guidebook is a "First Aid Manual" and should not be used as the only reference for action in the control of hazardous materials emergencies.

4. When the IC, Command Staff, and General Staff return, each group should discuss its responsibilities and actions to be taken for the scenario as follows:

Command:	Strategy (short-and long-term) and overall coordination, command Safety, Liaison, and Information activities
Staff:	Required to support the IC and operating forces at this incident
Operations:	Tactical assignments within the initial strategic goals, resource needs, Staging Area(s), and specialized resource needs.
Planning:	Gather Situation Status data, track Resource Status, obtain documents needed for the incident, and information on getting technical advisers
Logistics:	Divide the small group into two Branches (Service and Support). Have each Branch determine the needs and actions of its Branch in support of the resources operating at this incident
Finance:	Potential financial impacts of this incident, records that may be required to document expenses for cost recovery

5. Record your answers on flipchart paper as follows:

Command:	Short- and long-term strategies and organizational chart for IC, Command Staff, and General Staff
Command:	Actions taken by function (Safety, Liaison, and Information)
Operations:	Organizational chart for the Operations Section
Planning:	Organizational chart for the Planning Section: actions taken and tactical options
Logistics:	Organizational chart for the Logistics Section and actions taken
Finance:	Organizational chart for the fiance Section and actions taken.

6. 25 minutes will be allowed for small group work and 1 hour for reporting out

SCENARIO

Situation

At the off-ramp from the 5th Street Bridge, a 6,000-gallon tanker (tractor-trailer) carrying acrolein CH2CHCHO or C2Hc3CHO) has overturned. It is spilling its load down the street and into the river. Refer to the Emergency Action Guide provided on the following page for details about acrolein.

Conditions

It is 063- hours on Monday. The temperature is 62oF, humidity is 30%, with winds from the north at 5-10 mph.

Problem

Fire, Police, and EMS have been dispatched to the incident. A police officer, first on the scene, reports that the incident involved a hazardous material. He advises the communications center that the tanker has a red placard with the ID# 1092. Referring to the Department of Transportation Emergency Response Guidebook, you determine that the substance involved (based on the reported placard and ID#) is inhibited acrolein.

Upon your arrival at the incident, you observe moderate leakage from two dome covers on the truck (approximately 10 gallons per minute). The police officer reports that the driver is trapped in the vehicle and is unconscious or dead. The police officer then advises that he himself is having difficulty breathing.

Communications advises that a call has been received from the nursing home (located 700' to the east of the incident) reporting that several residents also are having difficulty breathing.

A short time later, communications advises that numerous calls are being received from the area south of the incident with reports of a foul odor and difficulty breathing being reported.

Refer to the drawing of the incident scene on the earlier page.

ACROLEIN, INHIBITED - 1092

GUIDE 30 - POTENTIAL HAZARDS INFORMATION SHEET

HEALTH HAZARDS

Poisonous; may be fatal if inhaled, swallowed or absorbed through skin.

Contact may cause burns to skin and eyes.

Runoff from fire control or dilution water may cause pollution.

FIRE OR EXPLOSION

Extremely flammable; may be ignited by heat, sparks, or flames.

Vapors may travel to a source of ignition and flash back.

Container may explode violently in heat of fire.

Vapor explosion and poison hazard indoors, outdoors, or in sewers.

Runoff to sewer may create fire or explosion hazard.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.

Stay upwind; keep out of low areas.

Self-contained breathing apparatus and chemical protective clothing which are specifically recommended by the shipper or producer may be worn but they do not provide thermal protection unless it is stated by the clothing manufacturer. Small Fires: Dry chemical, CO2, Halon, water spray, or standard foam.

Evacuate the leak or spill area immediately for at least 600 feet in all directions. The evacuation area may be increased to 1.5 miles in width and 3 miles in length downwind.

Isolate for 1/2 mile in all directions if tank car or truck is involved in fire.

Call CHEMTREC at (800) 424-9300

If water pollution occurs, notify the appropriate authorities.

FIRE

Small Fires: Dry chemical, CO_2, Halon, water spray or standard foam.

Large Fires: Water spray, fog, or standard foam is recommended.

Do not get water inside container.

Cool containers that are exposed to flames with water from the side until well after fire is out. Stay away from ends of tank.

For massive fire in cargo area, use unmanned hose holder or monitor nozzles; if this is impossible, withdraw from area and let fire burn.

Withdraw immediately in case of rising sound from venting safety device or any discoloration of tank due to fire.

SPILL OR LEAK

Shut off ignition sources; no flares, smoking, or flames in hazard area.

Do not touch spilled material.

Stop leak if you can do it without risk.

Use water spray to reduce vapors.

Do not get water inside containers.

Small Spills: Flush area; Structural firefighter's protective clothing is not effective with these materials.

Large Spills: Dike far ahead of liquid spill for later disposal.

FIRST AID

Move victim to fresh air; call emergency medical care.

If not breathing, give artificial respiration.

If breathing is difficult, give oxygen.

Remove and isolate contaminated clothing and shoes at the site.

In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes.

Keep victim quiet and maintain normal body temperature.

Effects may be delayed: keep victim under observation.

Adapted from Department of Transportation Emergency Response Guidebook, 1987 edition.

RESPONDING RESOURCES

All these resources will respond.

Fire Department and EMS

EMS truck with two paramedics dispatched. 1 pumper 4 men, 1 tanker with foam, 1 aerial company with 3 men, can call additional alarm if needed.

Law Enforcement

12 officers with squad cars
2 police shift commanders
Off-duty officers recalled

Outside Agencies/Representatives

Disaster Assistance Agencies
County Health Department
EPA
DOT
State Health Department
State Police
State Highway Department
State Fish and Game Department
Trucking company representative
Chemical company representative
Nursing home manager
Water and Sewer Department

Media

3 newspaper reporters
5 radio news staff members
4 TV reporters
2 TV station helicopters

Private Contractors

Ajax Hazardous Materials Recovery Co.
Joe's Sand and Gravel

GLOSSARY

This glossary includes ICS terminology and other terms used in this course.

Agency Representative. Individual assigned to an incident from an assisting or cooperating agency who has been delegated full authority to make decisions on all matters affecting that agency's participating at the incident. Agency Representatives report to the Incident Liaison Officer.

Allocated Resources. Resources dispatched to an incident that have not yet checked in.

Ambulance. A ground vehicle providing patient transport capability specified equipment capability and personnel (eg. basic life support ambulance or advanced life support ambulance, etc.).

Assisting Agency. An agency directly contributing suppression, rescue, support, or service resources to another agency.

Available Resources. Resources assigned to an incident and available for an assignment.

Base. That location at which the primary logistics functions are coordinated and administered. (Incident name or other designator will be added to the term "Base.") The Incident Command Post may be collocated with the base. There is only one base per incident.

Branch. That organizational level having primary and specific functional/geographic responsibility for major segments of incident operations. The Branch level is organizational between Section and Division/Group.

Brush Patrol. A light, mobile vehicle, having limited pumping and water capacity for off-road operations.

Chief. ICS title for individuals responsible for command of the functional Sections of Operations, Planning, Logistics, and Finance.

Clear Text. The use of plain English in radio communications transmissions. No Ten Codes or agency-specific codes are used when using Clear Text.

Command Officer. An officer who is not a part of the staffing of a Single Resource.

Command Staff. The Command Staff consists of the Information Officer, Safety Officer, and Liaison Officer, who report directly to the Incident Commander.

Command. The act of directing, ordering, and/or controlling resources by virtue of explicit legal agency or delegated authority.

Communications Unit. Functional Unit within the Service Branch of the Logistics Section. This Unit is responsible for the incident communications plan, the installation and repair of communications equipment, and operation of the incident communications center. Also may refer to a vehicle (trailer or mobile van) used to provide the major part of an Incident Communications Center.

Company Commander. The individual responsible for command of a Company. This designation is not specific to any particular fire department ranks (may be a Firefighter, Lieutenant, Captain, or Chief Officer, if responsible for command of a single Company).

Company. Any piece of equipment having a full complement of personnel.

Compensation/Claims Unit. Functional Unit within the Finance Section. Responsible for financial concerns resulting from injuries or fatalities at incident.

Cooperating Agency. An agency supplying assistance other than direct suppression, rescue, support, or service functions to the incident control effort (e.g., Red Cross, law enforcement agency, telephone company, etc.).

Coordination. The process of systematically analyzing a situation, developing relevant information, and informing appropriate command authority (for its decision) of viable alternatives for selection of the most effective combination of available resources to meet specific objectives. The coordination process (which can be either intra--or--inter-agency) does not in and of itself involve command dispatch actions. However, personnel responsible for coordination may perform command or dispatch functions within limits as established by specific agency delegations, procedures, legal authority, etc.

Cost Unit. Functional Unit within the Finance Section. Responsible for tracking costs, analyzing cost data, making cost estimates, and recommending cost-saving measures.

Crew Transport. Any vehicle capable of transporting personnel in specified numbers.

Crew. A specific number of personnel assembled for an assignment such as search, ventilation, or hoseline deployment and operations. The number of personnel in a crew should not exceed recommended span of control guides (3-7). A crew operates under the direct supervision of a crew leader.

Demobilization Unit. Functional Unit within the Planning Section. Responsible for assuring orderly, safe, efficient demobilization of resources committed to the incident.

Director. ICS title for individual responsible for command of a Branch.

Dispatch Center. A facility from which resources are directly assigned to an incident.

Dispatch. The implementation of a command decision to move a resource or resources from one place to another.

Division. That organization level having responsibility for operations within a defined geographic area. The Division level is organizational between the Single Resource, Task Force, or Strike Team and the Branch.

Documentation Unit. Functional Unit within the Planning Section. Responsible for Recording/Protecting all documents relevant to incident.

Engine Company. A ground vehicle providing specified levels of pumping, water and hose capacity, and personnel.

Engine. A ground vehicle providing specified levels of pumping, water, and hose capacity, but with less than the specified level of personnel.

Facilities Unit. Functional Unit within the Support Branch of the Logistics Section. Provides fixed facilities for incident. These facilities may include the Incident Base, feeding areas, sleeping areas, sanitary facilities, and a formal Command Post.

Finance Section. Responsible for all costs and financial considerations of the incident. Includes the Time Unit, Procurement Unit, Compensation/Claims Unit, and the Cost Unit.

Food Unit. Functional Unit within the Service Branch of the Logistics Section. Responsible for providing meals for personnel involved with incident.

Fuel Tender. Any vehicle capable of supplying fuel to ground or airborne equipment.

General Staff. The group of incident management personnel comprised of: the Incident Commander, Operations Chief, Planning Chief, Logistics Chief, and Finance Chief.

Ground Support Unit. Functional Unit within the Support Branch of the Logistics Section. Responsible for fueling/maintaining/repairing of vehicles and the transportation of personnel and supplies.

Group. That organizational level having responsibility for a specified functional assignment at an incident. (e.g., ventilation, salvage, water supply, etc.).

Incident Action Plan. The strategic goals, tactical objectives, and support requirements for the incident. All incidents require an action plan. For simple incidents the action plan is not usually in written form. Large or complex incidents will require that the action plan be documented in writing.

Incident Command Post (ICP). That location at which primary command functions are executed and usually collocated with the incident base.

Incident Command System (ICS). The combination of facilities, equipment, personnel, procedures, and communications operating within a common organizational structure with responsibility for the management of assigned resources to effectively accomplish stated objectives pertaining to an incident.

Incident Commander (IC). The individual responsible for the management of all incident operations.

Information Officer. Responsible for interface with the media or other appropriate agencies requiring information direct from the incident scene. Member of the Command Staff.

Initial Attack. Resources initially committed to an incident.

Kind. The basic nature or purpose of a Company (eg. Engine, Truck, etc.).

Ladder Company. See Truck Company.

Leader. ICS title for individuals responsible for command of a Crew, Task Force, Strike Team, or functional Unit.

Liaison Officer. The point of contact for assisting or coordinating agencies. Member of the Command Staff.

Logistics Section. Responsible for providing facilities, services, and materials for the incident. Includes the Communications Unit, Medical Unit, and Food Units, within the Service Branch and the Supply Unit, Facilities Unit, and Ground Support Units, within the Support Branch.

Medical Unit. Functional Unit within the Service Branch of the Logistics Section. Responsible for providing emergency medical treatment of emergency personnel. This Unit does not provide treatment for civilians.

Officer. ICS title for the Command Staff positions of Safety, Liaison, and Information. Also used when a single individual performs a unit function within Planning, Logistics, or Finance.

Operational Period. The period of time scheduled for execution of a given set of operation actions as specified in the Incident Action Plan.

Operations Section. Responsible for all tactical operations at the incident. Includes up to 5 Branches, 25 Divisions or Groups, and 125 Single Resources, Task Forces or Strike Teams.

Out-of-Service Resources. Resources assigned to an incident but unable to respond for mechanical, rest, or personnel reasons.

Overhead Personnel. Personnel who are assigned to supervisory positions, including Incident Commander, Command Staff, General Staff, Directors, Supervisors, and Unit Leaders.

Planning Meeting. A meeting, held as needed throughout the duration of an incident, to select specific strategies and tactics for incident control operations and for service and support planning.

Planning Section. Responsible for the collection, evaluation, dissemination, and use of information about the development of the incident and the status of resources. Includes the Situation Status, Resource Status, Documentation, Demobilization Units, and Technical Specialists.

Procurement Unit. A functional Unit within the Finance Section. Responsible for financial matters involving vendors.

Reporting Locations. Any one of six facilities/locations where incident-assigned resources may check in. The locations are: Incident Command Post - Resources Unit (RESTAT). BAse, Staging Area, or Division Supervisor for direct line assignments. (Check in at one location only.)

Rescue Company. A ground vehicle providing specified rescue equipment capability and personnel.

Rescue Medical. Any manned ground vehicle capable of providing emergency medical services.

Resource Status Unit (RESTAT). Functional Unit within the Planning Section. Responsible for recording the status of resources committed to incident and evaluation of: Resources currently committed to incident., the impact that additional responding resources will have on incident, and anticipated resource needs.

Resources. All personnel and major items of equipment available, or potentially available., for assignment to incident tasks on which status is maintained.

Safety Officer. Responsible for monitoring and assessing safety hazards or unsafe situations and developing measures for ensuring personnel safety. Member of the Command Staff.

Section. That organization level having functional responsibility for primary segments of incident operations such as: Operations, Planning, Logistics, and Finance. The Section level is organizational between Branch and Incident Commander.

Service Branch. A Branch within the Logistics Section. Responsible for service activities at incident. Components include the Communications Unit, Medical Unit, and Food Units.

Single Resource. An individual Company or Crew.

Situation Status Unit (SITSTAT). Functional Unit within the planning Section. Responsible for analysis of situation as it progresses. Reports to the Planning Section Chief.

Staging Area. That location where incident personnel and equipment are assigned on a immediately-available status.

The overall plan that will be used to control the incident. Strategic goals are broad in nature and are achieved by the completion of tactical objectives.

Strike Team. Specified combinations of the same kind and type of resources, with common communications and a leader.

Supervisor. ICS title for individuals responsible for command of a Division or a Group.

Supply Unit. Functional Unit within the Support Branch of the Logistics Section. REsponsible for ordering equipment/supplies required for incident operations.

Support Branch. A branch within the Logistics Section. Responsible for providing the personnel, equipment, and supplies to support incident operations. Components include the Supply Unit, Facilities Unit, and Ground Support Units.

Tactical Objectives. The specific operations that must be accomplished to achieve strategic goals. Tactical objectives must be both specific and measurable.

Task Force. A group of any type and kind of resources with common communications and a leader temporarily assembled for a specific mission.

Technical Specialists. Personnel with special skills who are activated only when needed. Technical Specialists may be needed in the areas of fire behavior, water resources, environmental concerns, resource use, and training. Technical Specialists report initially to the Planning Section but may be assigned anywhere within the ICS organizational structure as needed.

Time Unit. A functional Unit within the Finance Section. Responsible for record-keeping of time for personnel working at incident.

Truck Company. A ground vehicle providing an aerial ladder or other aerial device and specified portable ladders and equipment capability, and personnel (e.g., Engine Company, Truck Company, Rescue Company, etc.).

Type. The specific defined capability of a specified kind of company (e.g., pumping, hose, water, and staffing of an Engine Company).

Unit. That organization element having functional responsibility for a specific incident Planning, Logistic, or Finance activity.

Water Tender. Any ground vehicle capable of transporting specified quantities of water.

TACTICAL DECISIONS

I. Introduction

The primary objective in responding to hazardous materials incidents is to prevent or reduce detrimental effects to public health or to the environment. To accomplish this objective, it is necessary to:

- Identify the substance involved.
- Evaluate its behavior when released and its effects on public health and the environment.
- Initiate actions to prevent or modify its effects.

Using this information from the initial size-up, then taking into consideration special problems, the responder can achieve his objectives. The objectives of responding to a hazardous materials emergency are to:

- Prevent or reduce the loss of lives or injury to those involved in the incident, including responders, or to those in the surrounding area who could be affected by the hazards produced.
- Prevent or reduce loss of property or damage to property.
- Prevent or reduce the effects the incident could have on the environment.
- Restore the area to normal conditions.

During size-up a general picture of the Hazardous Material incident is developed in order to evaluate its impact. This process of identifying the substance involved, evaluating actual or potential impact on public health and the environment is incident (site) characterization.

II. Initial Characterization

Responders gather information concerning the materials involved, the hazardous conditions which exist, and attempt to determine the severity and effects the incident will have on the surrounding area.

The responder needs to place control measures into action immediately. This accomplished or while being accomplished, the responder needs to initiate other activities to restore the area to an environmentally acceptable condition. As mentioned in the Hazardous Recognition section, all of these activities are occurring simultaneously. The response team with a standard set of operating procedures or preplanned facilities is by far better able to handle an incident than an area with no team or pre-plan. Below is an outline to aid in collecting data needed to evaluate the impact of a hazardous materials incident. All incidents are different though some may be similar. The list provides a relatively detailed guide. However, the responder need not obtain all items, nor is the list inclusive.

Data gathering and preliminary assessment upon notification or discovery of an incident, should contain, the following information:

- Brief description
- Exact location
- Date and time of occurrence
- Hazardous materials involved and the physical and chemical properties

- Present status of incident
- Potential pathways of dispersion
- Habitation - population at risk, (special consideration, hospital, nursing home, etc.)
- Environmentally sensitive areas: endangered species, delicate ecosystems
- Economically sensitive areas: industrial, agricultural
- Accessibility by air and roads
- Waterways
- Current weather and forecast (need updates)
- Terrain: include topographic map
- Geology and hydrology: include appropriate maps
- Aerial photographs
- Communications
- The reading from monitoring equipment
- Any other related background information

Additional information may be available, especially about industrial waste sites, from:

- Federal agencies
- State and local health or environmental agencies
- Company records
- Court records
- Water departments, sewage districts
- State and local authorities.

III. Incident Strategy

The response team has completed the initial data gathering and preliminary assessment. Based on this information and a continuous evaluation of what is happening (update), many decisions need to be made, problems identified, priorities determined, a strategy (plan) developed, and tactics (actions) implemented.

Because each incident is different, the strategy used to prevent or reduce the potential effects on people, property, or the environment must be made to the specific conditions present (site specific). No rules are steadfast in the emergency response field. The strategy must be continuously reevaluated and changed, if necessary. A change in one or more existing conditions may cause the response team to implement an entirely different strategy.

The responder needs to understand that strategy and tactics are two different but inseparable components of emergency response operations. The two go hand in hand. One alone will fail.

> **STRATEGY** is the general plan or cause of action for preventing or reducing the effects of an incident.
>
> **TACTICS** are the methods and tasks used to accomplish the selected strategy.

In order to effectively develop and execute a specific strategy, responders must be trained and have available personnel equipment and other resources (mutual aid).

Response teams and areas that have pre-planned and practiced this plan, have a much better chance of controlling an emergency than a team that has not addressed, or half-heartedly addressed, the issue.

To establish a workable strategy, the responder needs to use all available information and establish priorities for operations. Tactics and options for controlling the various conditions created by the incident are evaluated along with expected results. The strategy is then implemented.

In addition to determining the materials involved and the associated hazards, other factors that are a priority in establishing a strategy:

- Need for immediate rescue or life-saving activities
- Protection of affected persons
- Responder safety
- Protection of property
- Protection of the environment
- Fire or explosions (or potential of)
- Potential container failure
- Availability of necessary resources
- Availability of time
- Weather conditions

Our first priority in developing a strategy (and the tactics to go with them) is to protect people. Secondary priorities are for protecting property and the environment. The strategy should minimize the effects of:

- Explosions
- Fires
- Releases of chemicals from their containers which could result in:
    - Toxic hazards from liquids, vapors or gases
    - Corrosive and reactive hazards
    - Radiation hazards
    - Biological hazards

IV. Incident Tactics

Having identified the problems and gathered all available information concerning the incident, the responder must implement the tactics. Tactics are methods, procedures, and techniques used to control the released materials, or in the case of a potential situation, preventing it from being released. The use of any tactic must be thoroughly evaluated. The action (tactic) must not contribute to the problem.

Several options may exist for controlling a certain situation. The benefits must outweigh the risk. In any option, protecting the health and safety of responders is always a factor.

Some tactics that are employed to prevent or reduce the hazards associated with chemicals are:

- Extinguishing fires and wetting areas
- Controlled burning or detonation
- Cooling containers (prevent BLEVE)
- Removing materials

- Plugging, patching, and other methods of containment to keep materials in their original containers
- Using dikes, berms, dams, and other techniques to confine fire or spilled material to the smallest possible physical area
- Using various chemical and physical methods to neutralize, absorb, dilute, transfer, dispense, solidify, as well as other methods to minimize hazards.

Most tactics used to protect people also protect property and the environment. The exception to this is removing people from the area. Tactics should also be updated and changed according to the changes in the characteristics of the incident. Once strategy and tactics have begun, the procedure of reevaluation should be continuous in order to safely gain control of the incident. The concept of incident control includes: suppressing the source, instituting appropriate and effective measures to limit the various hazards associated with material from happening; isolating the materials and hazards to the smallest possible physical area; and removing people from harm's way.

A. Life Saving Operations

1. Rescue

The response team learns through the size-up of an incident that civilians have been affected by the hazardous materials involved. The responder then has to consider rescuing any affected or endangered persons. There is a difference between endangered person and affected persons, for the responder.

- Endangered persons are those individuals directly involved in the incident who are in immediate jeopardy and who because of injury may not be able to leave the area of danger. These people will require a rescue.

- Affected persons are those whose health and safety are threatened. They include people adjacent to the incident as well as those that are subject to potential exposure to materials released in the air or surface water. It may be necessary for responders to evacuate these people.

A primary concern during rescue or evacuation is the safety of the responders. Responders should always determine and evaluate the risks versus the benefits before acting. It makes no sense to endanger oneself to rescue a body. Once the victim is deceased, the rescue becomes a recovery, which through evaluation changes the priority of the operation.

If a rescue is needed, responders should move the victim out of the danger area as quickly as possible. This will help ensure that the rescuers and the victim are not subjected to further hazards associated with the incident.

2. Evacuation

To simply remove people from the area of contamination is a common tactic--evacuation. It should be implemented as quickly as possible to allow for expected delays. The moving of people generally requires help. This task is generally delegated to law enforcement personnel. They can keep traffic flowing and provide security for the evacuated area. The responder must be certain that people being evacuated are not sent from an area of lesser danger to an area of greater danger: An example: A tank truck has spilled hazardous materials in an area adjacent to a parking lot, people in the building should not be allowed to leave the building to get their cars in the parking lot.

An alternative to evacuation in certain situations is staying inside and taking precautionary measures -- "Shelter-in-Place." If there is a one-time release, short duration release, or a very small release of hazardous materials in the air, shelter in place is generally the procedure. Shelter in place could mean moving people from one section of building to another, depending on location and the material. To shelter in place people should:

- Close all doors and windows; stuff towels under doors; and tape around windows.
- Turn off heating, cooling, or ventilation systems.
- Stop using the fireplace, put out the fire, and close the damper.
- Listen to local radio or TV stations for further instructions.

Special considerations must be given to groups of people in the evacuation area. The evacuation of schools, hospitals, jails, or nursing homes usually requires special arrangements. Certain people in the evacuation area may be confined to their home due to illness or injury, and special arrangements must be made for these people.

Most successful evacuations are based upon having evacuation methods and responsibilities assigned in a contingency plan (pre-plan). The unique populations may require medical treatment or care and/or special transportation. By pre-planning an evacuation, responders will minimize the risks to the health and safety of these groups as well as themselves.

B. Prevent Container Failure

1. Cool Containers

Applying large amounts of water to a container is probably the most common tactic used to cool the container. A minimum of 500 gallons per minute must be applied at the point of flame impingement. If there is more than one point of flame impingement, 500 gallons per minute is needed at each point. Water supply is critical. Knowing the capabilities of your equipment and water supply systems, is very important. Maintaining an adequate water supply may be difficult in areas without domestic water systems. Common problem areas are near interstate highways and railroad yards.

If available, heavy streams should be applied to the vapor space (the space inside the container above the liquid), as well as the point of flame impingement. If heavy flames and smoke are visible and the relief valve is operating, is likely that more and more of the product is being released into the environment. As the level of the product goes down, the vapor space increases. This vapor space, a critical area in the tank, is generally the point at which failure of the container occurs. Heavy streams of water must be applied to the vapor space to prevent a BLEVE. (Boiling Liquid Expanding Vapor Explosion).

The responder can generally find the line between liquid product and vapor on the outside of the tank by applying water. The vapor space area will be hotter and steam or sizzle. The tank will change colors sooner in the vapor area. Warping, buckling, or actual cave-in may be visible. The container may be making or begin to make different sounds. These signs are very important. This change in the container may dictate a change in tactics: to cease fire fighting and evacuate or to set up unmanned monitors. The monitors should be checked periodically but with a minimum of personal and exposure. These should not be shut-off between the end of the nozzle and the pump outlet. The pump operator controls the water flow.

2. Use Stress Barriers

Stress Barriers are sometimes used between the fire and containers to prevent container failure: (a) to absorb the radiant heat (b) or prevent the container from coming into contact with the flame.

3. Remove Uninvolved Materials

Removing unaffected containers should be performed with extreme caution. Some chemicals have stabilizers (inhibitors). Once exposed to fire, the chemical may lose its stabilizer making it explosive or reactive. Even after removing from the danger area, the containers should be monitored and maybe even cooled. Direct sunlight can affect the reaction of some chemicals, especially if already exposed to a fire.

C. Contain or Confine the Hazard

1. Containment - Stop the leak

The impact of an incident can greatly be reduced if the material is kept in its own container. The responder can achieve this simply by plugging openings, closing valves, tightening caps, or uprighting a container. This process can be as simple as putting a wooden dowel (peg) in a hole or as complicated as using a chlorine kit. Several considerations should be made to maintain safety:

- Decontamination needs to be set up prior to entry
- If pressure vessel approach from sides using extreme caution

- Check suit compatibility with hazardous material
- Check plug or patch compatibility with hazardous materials.

By all means, if one does not have the resources, i.e., protective equipment, reference materials, plugging or patching material, or decontamination equipment, this cannot be a safe operation, therefore the responder must wait for trained personnel or take other action to confine the spill.

2. Confinement: Construct a Barrier

The responder uses the tactic of confinement to minimize the effect of a spill by constructing barriers to control run-off. This dam or dike will keep the material to a small geographical area and will make clean-up operations smaller. A problem with confinement is the contaminated soil which has to be disposed of properly. This disposal procedure varies from jurisdiction to jurisdiction--site characteristic. Soil compatibility with the product is important. Sand will generally not hold gasoline. Again the responder's safety is of the utmost importance.

3. Remove ignition sources -

This tactic is very difficult to accomplish and usually involves the help of other people such as public utilities personnel and police. To remove all ignition sources, the responder should start from the downwind side and remove all sparks, heat, flames, or potential sources. This can be accomplished by turning the electricity off with the main breaker and the gas meter off as the supply enters the residence. The responder should be fully protected and should have monitoring being done. The responder should not enter a flammable or explosive environment. A general rule of thumb is if there is a flammable vapor or gas present and has not ignited - DO NOT TURN ON NOR OFF Any Switches Or Breakers. Removing ignition sources should be accomplished before the gas or vapor arrives.

4. Controlled burning

Controlled burning should be attempted only by <u>experienced</u> and <u>trained</u> personnel. It is a tactic, if safely accomplished, which can greatly minimize the effect of the incident. The responder actually ignites the hazardous material to allow the majority of the hazards to be burned off. Technicqes known as flaring are used, where a pipe is laid a safe distance from the incident and the product is flared (burned off). This is a very dangerous tactic for which a very detailed size-up is required. Chemicals change when exposed to heat, it is possible to make the incident worse by the smoke and fall out.

5. Transferring Products

There are numerous ways to transfer a product from one container to another, such as hot taps, discharge outlet, internal valve removal, vapor recovery line, dome cover funnel, etc. Regardless of the method used, the responder must remember to keep the operation safe. A combustible gas indicator must be used to monitor vapor levels at all times. The procedure will be stopped if vapors are detected by the CGI. Valves have to be replaced or plugs placed in holes drilled through the tanks prior to removal. Tanks should be braced to prevent shifting during offloading. All vehicles and equipment must be bonded and grounded. The bonding cable should attach to the accident vehicle first, then run to grounding rods, recovering broiler, spill tubs, down spouts, etc. The bonding and grounding prevents an electrical charge from building up and sparking which could ignite the vapors. Monitoring must be conducted throughout these procedures and should be conducted by trained personnel.

D. Extinguish Fires

1. Use proper extinguishing agent.

The tendency is to rush in and apply water to a fire, but when hazardous materials are involved more examination is needed. The proper extinguishing agent must be used. The extinguishing agent--whether water, dry powder, dry chemical, or foam--may react with the material on fire and complicate the incident. Responders must be sure not to mix incompatible agents. Generally, water streams are effective for extinguishing high flash point hydrocarbons such as kerosene and diesel. Foam or dry chemicals may be used for low flash point products such as gasoline. Dry powders should be used on water reactive materials. If an extinguisher is used, the responder must take precautions not to spread the burning material. Proper protection is required to apply any of these extinguishing agents. The responder should be in proper protective clothing even if using only a fire extinguisher on a small fire.

2. Remove Fuel - Remove Oxygen Supply

By closing valves or plugging leaks the responder can remove the fuel to extinguish the fire. This is an appropriate tactic for flammable liquids or gases. The responder may be able to smother the fire by removing the oxygen supply. The application of foam, sand, or dirt will usually accomplish this. These tactics should be practiced and conducted only by trained and experienced personnel.

3. Allow Substance To Burn.

The situation may be to dangerous to commit personnel for extinguishment or during size-up, it may be decided to allow the fire to burn in order to consume the hazardous material. Generally in large pesticide or poisonous gas fires, burning is the tactic used. The response team must be sure to evacuate downwind or any area effected by the smoke and fall out.

E. Protection from exposures.

1. Personnel, Equipment, and Vehicle Protection.

Protecting the responder is one of the primary concerns. An entire section is devoted to proper personnel protective clothing. Some general guidelines are:

- Always approach the incident upwind or at an angle.
- Vehicles should be parked at a safe distance, with engines off.
- Continual monitoring in rest area or safe zones.
- Proper protective clothing--suit compatibility (standard fire fighting gear is not chemical protective clothing).
- If personnel are committed, a rest area should be established and heat related injuries monitored.
- Potential flammable or explosive atmosphere should be avoided.
- A decontamination zone must be in place prior to entry.

2. Tactical Withdrawal

During size-up a withdrawal should be considered including routes and a meeting place for personnel accountability. Response personnel should continually re-evaluate the situation and update their tactics to allow for withdrawal without the possibility of being trapped. Sometimes, an entire command post must be moved because of changing conditions.

3. The use of Barriers

Responders may use explosion or fire proof barriers to help protect personnel and equipment. Natural barriers such as ditches, depressions, or levees may be considered. Hazardous materials properties must be known. If the material is gas and heavier than air, the material will be in the low areas. Crews and responders, if available, should be standing by to handle the spread of fire due to an explosion. If the material is known to be explosive, and there is a chance of ignition, an evacuation must be considered.

V. Critique the Incidents

In order for response teams to learn and to grow, each incident--no matter how large or small--should be honestly and openly critiqued. The critique session should be open to all participants--no matter what role they played. Prejudices and politics should be left out of the critique. The entire incident should be broken down by segments and problem areas identified. This allows the response team an opportunity to make changes and updates in their response plan.

VI. Summary

Each hazardous materials incident is different and must be sized-up accordingly. Strategies and tactics are based upon information learned during size-up. The strategy and tactics are based on availability of personnel, training, and equipment and must be continually reevaluated and updated. Responder protection and safety are of primary concern. Nothing can be as valuable as/or can take the place of, comprehensive emergency response pre-planning. Through pre-planning and practice, the response team knows its capabilities as well as its limitations. A very organized decision-making process should be used to develop strategy and tactics.

Response personnel should:

- Have a standard operating procedure (SOP) and safety plan.
- Size up the conditions present and anticipate changes.
- Define the problems.
- Establish priorities and perimeters.
- Evaluate all possible courses of action considering resourses available and response limitations.
- Formulate strategy and tactics based on what will be done, how it will be done, and expected results.
- Establish a withdrawal plan with meeting point to account for personnel.
- Put strategy in operation, monitoring the conditions during process.
- Review the incident and modify the plan for future incidents.

FIELD MONITORING

I. Introduction

When responding to hazardous materials incidents, first responders must adequately assess the hazards present based on various data. An important element of the data is the identity of a chemical and the amount present. Assessing this can be relatively easy for solids or liquids, however, when dealing with gases, the assessment can become quite difficult.

In this section, a process for identifying an unknown chemical as well as the concentration of a known chemical are discussed together with various types of direct reading instruments, their uses, and their limitations.

One point that first responders should be aware of is the field monitoring data that are retrieved in an emergency situation quite often are very limited. The idea that purchasing an expensive detection device will solve all problems in assessing the identity and concentration of a chemical is simply not true. Identifying and assessing the quantity of a chemical is very difficult to do with the devices presently available to first responders. Although the data may be some what limited, their usefulness can be greatly enhanced by a good understanding of the device being used.

II. Identification of Unknowns

The initial objective of an on-site survey is to determine, on a preliminary basis, hazardous or potentially hazardous conditions. The main effort is to rapidly identify immediate hazards that may affect response personnel, the public, or the environment. The real or potential dangers from radiation, fire, explosion, oxygen deficient atmospheres, and airborne contaminants are a major concern. After the preliminary survey is completed, more detailed analysis can be performed to determine the exact identity, or at least the class of chemical present.

The following is an example of steps that can be followed to allow the first responder to test for specific hazards.

STEP 1 - Radioactivity

STEP 2 - Combustibility

STEP 3 - Oxygen availability (deficiency)

STEP 4 - pH (if liquid)

STEP 5 - Organic vapors

STEP 6 - Inorganic vapors

III. Direct reading instruments of each hazard.

A. Radiation

Three forms of radioactivity exist: alpha and beta particles and gamma rays. Alpha particles have very little penetrating power and are considered an internal hazard that can be absorbed into the body through the respiratory tract, the food chain, open wounds, or body orifices. Beta particles have a wide range of energies and are considered to be intermediate between alpha and gamma radiation in their penetration. Beta particles are capable of penetrating the outer layers of the skin, but they are easily shielded against. They are primarily (although not always) an internal radiation hazard. Gamma radiation, however, is not a particulate and can penetrate many objects, including the human body. To protect oneself from radiation, two objectives can be utilized: distance and shielding.

If the responders feel that radioactive materials may be involved, a survey for radiation should be conducted immediately. Normal background exposure-rate for gamma radiation is approximately 0.01 to 0.02 milliroentgen per hour (mR/hr) and may vary from region to region. Any detection above background radiation should dictate the need for additional help from experts in the field of radiation protection. These experts can be found in numerous states or from the Environmental Protection Agency (EPA).

There are numerous radiation detection devices (survey meters) available. The primary instruments used by emergency response personnel today consist of the dosimeter, the CDV 700-low level detection, and the CDV 715 - high level detection. The dosimeter is used to monitor the amount of radiation a responder is exposed to over a period of time. The CDV 700 on CDV 715 meters are used to measure the amount of radiation which a worker could be exposed. These meters are usually available through local civil defense agencies along with operational training.

B. Combustibility

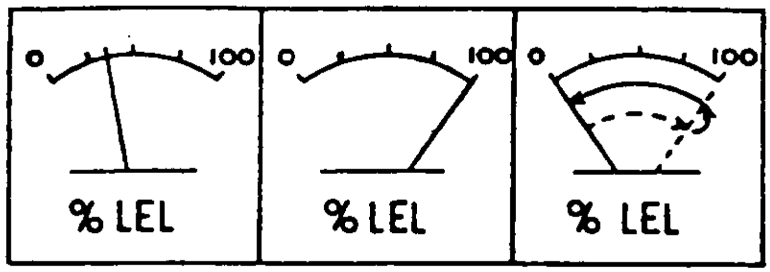
The most common instrument to detect combustibility is the Combustible Gas Indicator (CGI). CGI's measure the concentration of a flammable vapor or gas in air, indicating the result as a percentage of the lower explosive limit (LEL), not the percent of gas or vapor in air.

The LEL of a combustible gas or vapor is the minimum concentration of the material in air which will propagate flame on contact with an ignition source. The maximum concentration of the material in air which will propagate flame on contact with an ignition source is called the upper explosive limit (UEL). Above the UEL, the mixture is too "rich" to burn. Below the LEL, the mixture is too "lean" to burn.

1. Principle of Operation

Combustible gas indicators use a combustion chamber containing a filament that combusts the flammable gas. To facilitate combustion, the filament is heated or is coated with a catalyst (like platinum or palladium). The filament is part of a balanced resistor circuit called a Wheatstone Bridge. The hot filament combusts the gas on the immediate surface of the element, thus raising the temperature of the filament. The temperature change alters the resistance which causes an imbalance in the Wheatstone Bridge. This is measured, as the ratio of combustible vapor present compared to the total required to reach the LEL. For example, if the meter reads 0.5 (or 50%, depending upon the readout), this means that 50% of the concentration of combustible gas needed to reach a flammable or combustible range is present. Thus, the typical meter readout indicates concentrations up to the LEL of the gas.

If a concentration greater than the LEL and lower than the UEL is present, then the meter needle will stay beyond the 1.0 (100%) level. This indicates that the ambient atmosphere is readily combustible. When the atmosphere has a gas concentration above the UEL, the meter reading could rise above the 1.0 (100%) level and then return to zero (some of the newer or more expensive CGI's lock at the 1.0 (100%) level until completely purged.) The reason some meters will return to zero is because the gas mixture in the combustion cell is too rich to burn. This permits the filament to conduct a current just as if the atmosphere contained no combustibles at all. The following chart displays the different readings and their meanings in relationship to the test gases LEL.



a — Lower than the LEL

b — Between the LEL and the UEL

c — Above the UEL

2. Limitations and Considerations

a. Temperature

If the temperature at which the instrument is zeroed differs from the sample temperature, the accuracy of the reading is affected. Hotter temperature raise the temperature of the filament and produce a higher than actual reading. Cooler temperatures will reduce the reading. Calibrate and zero the instrument to the sample temperature.

b. Oxygen Content In Air

These instruments are intended for use only in normal oxygen atmospheres. Oxygen-deficient atmospheres will produce lower readings. The safeguards that prevent the combustion source from igniting a flammable atmosphere are not designed to operate in an oxygen-enriched atmosphere.

c. Contaminants

Certain contaminants, such as organic lead vapors (e.g., gasoline vapors), sulfur compounds, and silicone compounds will foul the filament. Acid gases (e.g., hydrogen chloride and hydrogen fluoride) can corrode the filament. Most units have an optional filter that protects the sensor from lead vapors.

C. Oxygen Availability (Deficiency)

Normal concentration of oxygen in air is 20.9%. Generally, if the oxygen content decreases below 19.5%, conditions become extremely hazardous and special respiratory protection is needed.

The concentration of oxygen in air is needed for a number of considerations: (a) the increased risk of combustion in oxygen-enriched (above 25%) atmospheres; (b) the use of other instruments can depend on sufficient oxygen for operation; and (c) a decreased oxygen concentration can indicate the presence of other contaminants.

Oxygen - deficient atmospheres may occur in unventilated areas or may be due to terrain variations in cases where vapors may collect. Most indicators have meters which display the oxygen concentration from 0% to 25%.

1. Principle of Operation

Oxygen indicators have two principal components, the oxygen sensor and the meter readout. The oxygen detector uses an electrochemical sensor to determine the oxygen concentration in air. A typical sensor consists of two electrodes; a housing containing a basic electrolytic solution, and a semipermeable teflon membrane.

Oxygen molecules diffuse through the membrane into the solution. Reactions between the oxygen, the solution, and the electrodes produce a minute electrical current proportional to the oxygen content. The current produced passes through the electronic circuit. The resulting signal is shown as a needle deflection on a meter or digital reading.

2. Limitations and Considerations

a. Pressure

The operation of oxygen meters depends on the absolute atmospheric pressure. While the actual percentage of oxygen does not change with altitude, at sea level the weight of the atmosphere is greater, and more oxygen molecules are compressed into a given volume of air than at higher elevations. As elevation increases, this compression decreases, resulting in fewer air molecules being "squeezed" into the same volume. Because of the dependency of the meter on pressure, it is necessary to calibrate the meter at the altitude the instrument is to be used.

b. Life of Sensor

Certain contaminants (such as carbon dioxide) can shorten the life of the oxygen sensor. Life-time in a normal atmosphere can be from one week to one year depending on the manufacturer's design.

c. Temperature

Temperature can affect the response of oxygen indicators. The normal operating range is between 32°F and 120°F. Between 0°F and 32°F the response of the unit is slower. Below 0°F the sensor may be damaged by the solution freezing. The instrument should be calibrated at the temperature at which it will be used.

d. Contaminants

Strong oxidizing chemicals, like ozone and chlorine, can cause increased readings and indicate high or normal oxygen content when the actual content is normal or even low.

D. Organic Vapors

The two types of instruments most commonly used to detect organic vapors are photoionization detectors (PID) and flame ionization detectors (FID). The PID can detect organic vapors and some inorganics whereas the FID can detect only organic vapors. The uses of these instrument are very broad (e.g., using the PID to determine the concentration of each of two or more chemicals) and require a great deal of training to fully understand how to utilize them.

1. Photoionization detectors

These instruments detect concentrations of gases and vapors in air by utilizing an ultraviolet light source to ionize the airborne contaminant. Once the gas or vapor is ionized in the instrument, it can be detected and measured.

a. Principle of operation

All atoms and molecules are composed of particles: electrons, protons and neutrons. Protons, and neutrons are located in the nucleus of the atom and the electrons rotate in orbit around the nucleus. The electrons are held in place by their negative charge which is attracted to the positively charged protons in the nucleus.

The outermost electron of an atom is called the valence electron. A PID upon detecting the presence of a chemical, removes this electron by striking it with ultraviolet light. The amount of energy (measured in electron volts) required to remove the valence electron is called the ionization potential (IP).

To be able to use a PID, the ionization potential of the chemical in question must be known. This information can be found for most chemicals in the NIOSH Pocket Guide to Hazardous Materials. The strength of the lamp in the probe of the PID must be stronger than the IP of the chemical being detected or measured. The strength of lamps range from 8.3eV to 11.8eV. Some common chemicals and their ionization potential are listed below.

CHEMICAL	**IONIZATION POTENTIAL (eV)**
Hydrogen Cyanide	13.9
Methane	13.0
Oxygen	12.1
Chlorine	11.5
Propane	11.1
Ammonia	10.1
Benzene	9.2
Triethyl Amine	7.5

b. Limitations

The ability to detect a chemical depends on the ability to ionize that chemical. The IP of a chemical to be detected must be compared to the energy generated by the UV lamp of the instrument. As shown in the table earlier some chemicals have an IP stronger than the available lamps, therefore they can not be detected by a PID.

Dust in the atmosphere can collect on the lamp and block the transmission of UV light thus causing a reduction in the instrument reading. This problem will be detected during calibration and should then be corrected by simply cleaning the lamp.

Humidity in the atmosphere can cause two problems: (a) moisture can condense on the lamp and reduce the available light or (b) it can reduce the ionization of chemicals and cause a reduction in readings.

The age of the lamp will affect the reading because as the lamp ages the intensity of the light decreases. This problem will be detected during calibration and can be compensated for. Like other detectors, PIDs are calibrated for one specific chemical. The response to other chemicals can vary, however this response is constant for each chemical. By using a relative response chart the variation can be compensated for.

2. Flame ionization detector (FID)

These units utilize combustion as the means to ionize airborne contaminants. Once they are ionized, they can be detected and measured.

a. Principle of operation

FIDs use a hydrogen flame as the means to ionize organic vapors.

b. Limitations

(1) FIDs respond only to organic compounds.

(2) FIDs must also be calibrated to a specific chemical, therefore the response to other chemicals may vary. However, as with other detectors, this can be compensated for by using an appropriate relative response chart.

E. Inorganic Vapors

The most common detector used to detect inorganics is colorimetric indicator tubes.

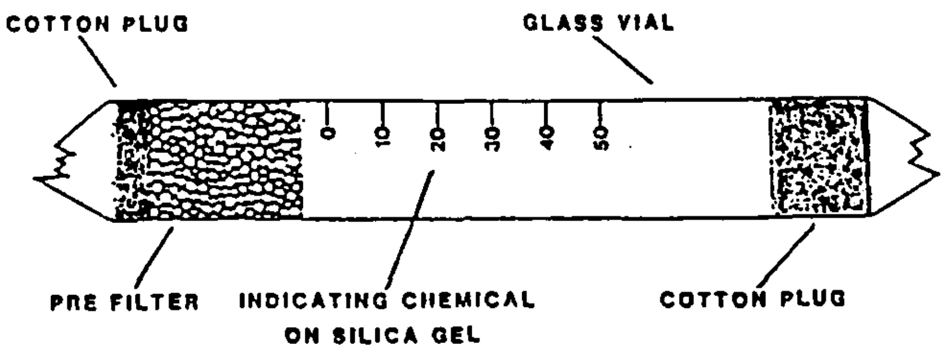
1. Colorimetric indicator tubes

These detectors are used by many first response organizations and have proved to be very effective when properly utilized.

a. Principle of operation

Colorimetric indicator tubes consist of a glass tube filled with an indicating chemical. The tube is connected to a piston or bellows type pump so that a known volume of contaminated air can be pulled through the tube. As the contaminant is drawn through the tube it reacts with the indicating chemical causing a color change. The length of the color change can then be used to determine the concentration of the contaminant.

Because chemical reactions will vary with different chemicals a specific tube must be used to detect the concentration of a known contaminant. Sometimes the tubes will utilize a filter to remove contaminants or to react with the contaminant to change it into a compound that will react with the indicating chemical.



A DIAGRAM OF A TYPICAL COLORIMETRIC TUBE

B. Limitations

Poor accuracy is the biggest disadvantage of detector tubes. In the past, NIOSH tested and certified detector tubes that were submitted to them. For the tubes tested, they certified the accuracy to be + or - 35% at concentrations at 1/2 the OSHA Permissible Exposure Limit (PEL) and + or - 25% at 1 to 5 times the PEL.

Temperature can affect the reading because it will affect the chemical reaction. Because of this, any tubes stored in a refrigerator should be warmed to ambient temperature before use.

Without a filter, humidity could affect the reading. Sometimes manufactures will provide a correction factor chart to compensate for this.

The chemical used in the tubes deteriorates over time. Thus the tubes are assigned a shelf life. This varies from 1 to 3 years. For some tubes refrigeration is used to prolong their life but the tube should be brought to ambient temperature before use.

The amount of time required to conduct a test can require up to 30 minutes because of the volume of air that must be drawn through some tubes.

IV. Summary

The data collected by direct reading instruments can prove to be invaluable to first responders. Yet if this same information is not fully understood (including limitations) it could prove to be very misleading and ultimately cause injury to the responders or the public. Direct reading instruments must be calibrated and field tested periodically to ensure that the data being retrieved is accurate. Because of many limitations, data gathered during emergency situations should always be reconfirmed by continuously monitoring the atmosphere.

RESPIRATORY PROTECTION

I. Introduction

One of the most important devices that first responders rely on today is the respiratory protection device. First responders often find themselves in situations that could be harmful to the body by simply breathing. These situations may vary from very small concentrations of a toxic chemical to high concentrations of an inert chemical that has displaced the oxygen in the atmosphere. By design, the respiratory system has the ability to rid itself of some contaminants, but this ability can be overcome rapidly when certain chemicals are present. The respiratory protection devices discussed can be divided into two classifications according to their mode of operation: (a) air purifying respirators (APRs) remove the contaminants by passing the breathed air through a purifying element; (b) atmosphere supplying respirators provide a substitute source of clean breathing air. This source of air can be either stationary and provided to the user by a hose, or the source can be carried by the user. Because of the varying conditions to be encountered by first responders, the respiratory protection most commonly utilized is the atmosphere supplying respirator which is carried by the user and called the self contained breathing apparatus (SCBA). We will discuss these devices and the selection process in great detail.

II. Respiratory Hazards

Three possible situations can be encountered by the first resonder that would dictate the need for respiratory protection: (a) an unknown identity or concentration of a contaminant; (b) a known identity and concentration of a containment which is above the safe limit of exposure; or (c) an oxygen deficient atmosphere.

A. Unknown identity or concentration

Quite often first responders are called upon to perform rescue procedures in atmospheres of unknown identities or concentrations of a contaminant. These situations are very dangerous and the responders should utilize the respiratory protection device that affords them the maximum amount of protection. Contaminants can be present in the form of particulates or gases. Particulates are fine particles (solid or liquid) suspended in air and can cause various local or systemic damage to responders. Gases are dispersed in air and can also cause various local or systemic damage to responders.

B. Known identity and concentration

Situations may be present in which first responders have identified the contaminant and with direct reading instruments determined its concentration. When this is the case, responders must research information on the contaminant present to determine what type, if any, hazard exists. Depending on the hazard present the responder may choose respiratory protection devices which offer minimal or maximum protection.

C. Oxygen deficiency

The body requires oxygen to survive. The normal concentration of oxygen in air is 20.75. 20.9% First responders can encounter situations where the contaminant and its concentration have been identified and present no chemical or physiological hazard except that it has diluted the oxygen concentration in the air. Physiological effects of oxygen deficiency are:

- Loss of peripheral vision
- Increased breathing rate
- Accelerated heart beat
- Impaired attention and thinking
- Impaired coordination
- Faulty judgment
- Poor muscular coordination
- Intermittent respiration

These are generally not apparent until the concentration decreases to 16% or less. Because of errors in measurement, individual physiological responses and safety considerations, first responders should consider any atmosphere containing less than 19.5% oxygen as being oxygen deficient. Oxygen deficient atmospheres require that first responders utilize SCBAs for their respiratory protection. Any confined space, low lying or poorly ventilated area, should be checked for oxygen deficiency prior to entry.

III. Components of Respiratory Protection Devices

The two main components of any respiratory protection device are the facepiece and the air purifying or supplying component. These components compromise the entire respiratory protection device and are equally important in its operation.

A. Facepiece

The protection provided for the wearer of a respirator is a function of how well the facepiece fits. No matter how efficient the purifying element or how clean the supplied air, there is little protection afforded if the respirator mask does not provide a leak-free facepiece-to-face seal. Facepieces are available in three basic configurations which relate to their protective capacity.

1. Quarter mask

The quarter-mask fits over the bridge of the nose, along the cheeks and across the top of the chin. Headbands are used to secure the mask to the face and are attached at two or four places on the mask. This facepiece provides its user with the minimum protection. The respirator can be easily dislodged, creating a breach in the seal.

2. Half-mask

The half-mask fits over the bridge of the nose, along the cheeks, but unlike the quarter-mask it seals under the chin. By securing under the chin, a more sturdy and effective seal can be provided than with a quarter mask. The headbands used to secure the facepiece are attached in four places (four/point suspension).

3. Full-facepiece

The full-facepiece fits across the forehead, down over the temples and cheeks, and under the chin. They typically have a head harness with a five or six point suspension. These mask give the greatest protection because they are held in place more securely and it is easier to maintain a good seal along the forehead than across the bridge of the nose. An added benefit is the eye protection from the clear lens in the full-facepiece.

Not all facepieces fit everyone the same, so each individual must find out which manufacturer's mask he or she can properly wear. To do this a **FIT TEST** must be performed with the specific facepiece to be utilized by the first responder.

4. Fit testing

There are two types of fit tests: quantitative and qualitative. The quantitative test is an analytical determination of the concentration of a test agent inside the facepiece compared to that outside the mask. This ratio is called the protection factor (PF) and is a measure of the relative protection offered by a respirator. For example, if the ambient concentration of the test agent is 1000 ppm and the concentration inside the mask is 10ppm, the respirator gives the tested individual a AF of 100. The formula to determine PF is:

$$PF = \frac{\text{CONCENTRATION OUTSIDE MASK}}{\text{CONCENTRATION INSIDE MASK}}$$

Common problems that could cause the wearer not to get a good facepiece-to-face seal are: facial hair, skullcaps, long hair, make-up, or temple pieces on eyeglasses. These problems should always be avoided.

Because quantitative test are expensive and tedious, qualitative test are more often performed to check respirator fit. A qualitative fit test is not an analytical measurement. It is a subjective test during which an aroma or irritant is used to determine if there is a good facepiece-to-face seal. If the test subject does not respond (by smelling, tasting, or coughing) to the test agent, he/she can wear the tested respirator with the (APF) assigned protection factor given to that mask by NIOSH.

The following are some APFs given by NIOSH to specific types of respirators:

Air Purifying

quarter-mask - - - - - - - - - - 5

half-mask - - - - - - - - - - - 10

full facepiece - - - - - - - - 50

SCBA, Demand

full facepiece- - - - - - - - 50

SCBA, Pressure-demand

full facepiece - - - - - - - 10,000

A protection factor is used to determine the maximum use limit (MUL) of a successfully fit tested respirator. The MUL is the highest concentration, not exceeding IDLH concentration, of a specific contaminant in which a respirator can be worn.

MUL = PF X TLV

For example, if a contaminant has a TLV-TWA of 10 ppm, then the MUL for any half-mask respirator is 100 ppm: the MUL for a ful-facepiece APR or demand SCBA is 1000 ppm. If the ambient concentration is greater than 1000 ppm, then a pressure demand SCBA is required.

B. Air purifying or supplying component

The second part of a respiratory protection device either purifies or supplies air. For air purifying respirators, it is the cartridge or the canister that breathing air is passed through. For the air supplied respirators, it is a compressed air cylinder and regulator or a compressor and regulator.

1. Cartridge/Canister

This device functions by removing contaminants from the breathing air before they enter the users body. The operation depends on whether the contaminant is a particulate or a gas.

a. Removal of particulates

The removal of particulates from breathing air is done mechanically. Breathing air is passed through a filter where the particulates are captured and held. These filters load with particulates as they are used, not only becoming more and more efficient, but also become more difficult to breathe through. When a mechanical filter becomes difficult to breath through, it should be replaced.

b. Removal of gases

Gases and vapors are removed from the breathing air by passing the air through a cartridge that contains a chemical sorbent. As gases pass through the sorbent, they are scrubbed form the air.

Selecting a gas removing element, involves choosing for the protection against a specific type of contaminant. They are available in many different styles to suit the specific situation at hand.

Each sorbent has a finite capacity for removing contaminants; when this limit is reached, the cartridge or canister is said to be saturated. At this point the cleaning element will allow the contaminant to pass through and enter the facepiece. The length of time a cartridge or canister will effectively remove the contaminant is known as the service life of the element. The service life is dependent on several factors: the breathing rate of the wearer, contaminant concentration, and sorption efficiency.

2. Compressed air cylinders

Compressed air cylinders are used to store an air supply for the first responder. This air supply is then delivered to the user at reduced pressure via a regulator. There are various types of compressed air cylinders. Some contain large volumes of air that are in a stationary position (usually on a trailer or response vehicle) called a cascade system and others that are carried by the responders, such as the cylinders utilized with SCBAs.

a. Cascade systems

Cascade systems consist of large compressed air cylinders that are mounted and linked together with a valving assembly making them operate as one large cylinder. These systems can consist of two to twelve (and sometimes more) cylinders. The breathing air is sent to the first responder via a high pressure hose. The responder wears a regulator system to reduce the pressure and to keep a constant flow of breatheable air.

b. SCBA Cylinder

These cylinders generally contain 45 cubic feet of Grade D air at a pressure of 2,216 pounds per square inch (psi) which is needed for a 30-minute supply. Cylinders are filled, using a compressor or a cascade system of several large cylinders of breathing air.

If the cylinder is overfilled, a rupture disc releases the pressure. The rupture disc is located near the cylinder valve, together with a cylinder pressure gauge which should be accurate within + or - 5%.

Compressed air is considered a hazardous material. For this reason, cylinders used with an SCBA must meet the Department of Transportation's (DOT) requirements for shipping it.

A hydrostatic test must be performed on a cylinder at regular intervals: every 5 years for steel and aluminum cylinders; for composite cylinders (glass fiber/ aluminum), every 3 years. Composite cylinders are relatively new, designed with fiberglass. The construction technology reduces the weight of the cylinder and thereby the overall weight of the SCBA.

IV. Types of Respiratory Protection Devices

Two types of devices are utilized in the emergency response field: (a) air purifying respirator and (b) air supplying respirator.

A. Air purifying respirators

Air purifying respirator uses are very limited to the emergency response field because of the large number of selection criteria that must be met prior to their use. Some selection requirements that must be met include:

- The identity and concentration of the contaminants are known.
- The ambient concentration of a contaminant is below the Immediately Dangerous to Life and Health (IDLH) concentration.
- The oxygen content in the atmosphere is greater than 19.5%.
- The respirator assembly is approved for protection against the specific concentration of a contaminant.
- There is periodic monitoring of the work area.
- The respirator assembly has been successfully fit tested on the user.

The most encountered problem facing first responders which causes them not to be able to utilize an air purifying respirator is the fact that they do not know the exact concentration of the chemical involved.

B. Air supplying respirators

Air supplying respirators are the most frequently used respiratory protection devices during response to hazardous materials incidents. If the contaminant is unknown or the requirements for using air purifying respirators cannot be met, then an atmosphere supplying respirator is required. Several types of atmosphere supplying devices are available:

- Oxygen generating respirators which utilize a canister of a chemical such as potassium superoxide. The chemical reacts with water vapor to produce oxygen which replenishes the wearer's exhaled breath.
- Hose mask respirators that consist of a facepiece attached to a large diameter hose which transports clean air from a remote area.
- Airline respirators like hose mask, except that they provide breathing grade air to the wearer under pressure- either from a compressor or a bank of compressed air cylinders.
- Self-contained breathing apparatus that consist of a facepiece and regulator mechanism connected to a cylinder of compressed air or oxygen carried by the wearer.

The SCBA is generally the choice of first responders because it allows the wearer to work without being confined by a hose or airline.

1. SCBA's modes of operation

   a. Demand

      In the demand mode, a negative pressure is created inside the facepiece, and breathing-air is then released for the responder. This negative pressure created in the facepiece draws down a diaphragm in the regulator of the SCBA. The diaphragm depresses and opens the admission valve, allowing air to be inhaled. As long as negative pressure remains, air flows to the facepiece.

The problem associated with demand operation is that the wearer can inhale contaminated air through any gaps in the facepiece-to-face sealing surface.

b. Pressure demand

An SCBA operating in the pressure demand mode maintains a positive pressure inside the facepiece at all times. The system is designed so that the admission valve remains open until enough pressure closes it. The pressure builds up because air is prevented from leaving the system until the wearer exhales. Less pressure is required to close the admission valve than is required to open the spring-loaded exhalation valve.

Because the pressure remains in the facepiece at all times, the user is afforded a much higher level of protection by not allowing any contaminants to enter through gaps in the facepiece-to-face sealing surface.

2. SCBAs (Types of apparatus)

a. Closed circuit

Commonly called the rebreather the closed circuit SCBA was developed especially for oxygen deficient situations. Because it recycles exhaled breath and carries only a small oxygen supply, the service time can be considerably greater than an open circuit device, which must carry all of the user's breathing air.

These apparatuses can be easily detected by two breathing tubes connected to the facepiece, one for inhaled and one for exhaled air.

b. Open circuit

This apparatus requires a supply of compressed breathing air. The user simply inhales a portion of the compressed air delivered to him/her and exhales into the ambient atmosphere via an exhalation valve located in the facepiece. These units are available that can last from 5 to 60 minutes.

Because 60 minute units are now available, closed circuit units are becoming less and less utilized.

3. Components of a SCBA

   a. Cylinder: the device that contains the compressed air

   b. High pressure hose: connects the cylinder and regulator

   c. Alarm: a device that sounds to alert the wearer that only 20-25% of the air supply remains.

   d. Regulator assembly: reduces the pressure of the cylinder to a pressure the wearer can breathe. Two valves are located here: (a) MAIN LINE VALVE which is open during normal operation and (b) BYPASS VALVE which is opened when a malfunction of the regulator assembly occurs. Once the by-pass valve is open, the wearer should immediately exit the contaminated area.

   e. Breathing hose: connects the regulator to the facepiece.

f. Facepiece: is normally constructed of neoprene, but sometimes of silicone rubber and a lens normally made of polycarbonate for clear vision that is also chemical resistant.

g. Back pack and harness: support the cylinder and regulator, allowing the user to move freely. Weight should be supported on the hip not the shoulders.

4. Inspection, donning, and doffing

Inspection, donning, and doffing are specific to the type and brand of SCBA used. The first responder must review and understand the information concerning these procedures provided with their SCBA's.

IV. Summary

First responders have many decisions concerning the respiratory protection that are necessary for the situation at hand. These decisions can be summarized and grouped into categories: (a) whether or not protection is required, and (b) what type of device should be used. Protection is needed when: (a) the contaminant in the atmosphere is unknown, (b) its concentration is unknown, (c) if the concentration is above a toxic limit or (d) in an oxygen deficient atmosphere.

The device chosen should provide the responder the needed protection while still allowing the maximum amount of work to be performed. The two devices, air purifying which provides limited protection but better work performance and air supplying which provides maximum protection but limited work performance should each be evaluated.

Respiratory protection is of utmost importance and should always be monitored to ensure adequate protection. If any questions are unanswered or not fully confirmed the first responder should always err to the side of caution and be safe "wear the SCBA."

PERSONAL PROTECTIVE CLOTHING

I. Introduction

Whenever there is the possibility of coming in contact with hazardous materials, some type of protective clothing must be worn. There are four basic categories of chemical protective clothing with several different types of suits in each category. For a responder to properly protect himself/herself he/she must fully understand these categories and the limitations of the different types of suits. If nothing else is learned in this chapter, the one thing that must be understood is: **"NO ONE SUIT IS GOOD IN ALL SITUATIONS."** One may offer a great amount of protection in one emergency and little or no protection in another.

I. Levels of protection

The EPA classifies chemical protective clothing into four levels, depending on the amount of protection offered by each. Three main areas of protection determines the categorization this clothing, the amount of protection offered to the skin, eyes, and respiratory tract. They range from Level D (offering no protection from chemicals) through Level A (offering the maximum amount of protection in all areas)

<u>Chemical Protection</u> <u>NONE</u> <u>LESSER DEGREE</u> <u>HIGHER DEGREE</u>

<u>Level D</u>

Eyes------------------------------
Skin------------------------------
Respiratory-----------------------

<u>Level C</u>

Eyes--
Skin--
Respiratory---------------------------------------

<u>Level B</u>

Eyes--
Skin--
Respiratory---

<u>Level A</u>
Eyes---
Skin---
Respiratory---

1. Level D

A. The lowest level of protection set down by the EPA, is considered to be nothing more than a work uniform required of everyone at a facility, waste site, or scene of an emergency. This level provides no protection to the wearer against chemical hazards, only protection from physical hazards.

B. Equipment needed

1. Coveralls

2. Boots/shoes, chemical-resistant steel toe and shank

Optional equipment

3. Gloves

4. Disposable boot covers

5. Safety glasses or goggles

6. Hard hat

7. Escape mask

8. Face shield

C. Selection

Level D protection should be worn when:

1. An atmosphere contains no known chemical hazards.

2. Work functions preclude splashes, immersions, or the potential for unexpected inhalation of or contact with hazardous levels of any chemicals.

2. Level C

A. This level of protection affords or offers the wearer some protection from chemicals, however, it is limited in all three areas of protection. This level can be worn in hazardous situations, but many questions have to be answered beforehand such as the identity of the chemical and the concentrations to be encountered by the responder. Thus makes Level C is very limited to the first responder and is used most often in remedial type operations.

B. Equipment needed

1. Full-face or half-mask air purifying respirator (NIOSH approved)
2. Hooded chemical resistant clothing (one or two piece of the disposable or reusable type)
3. Chemical resistant outer gloves
4. Chemical resistant inner gloves
5. Chemical resistant boots, steel toe and shank

Optional Equipment

6. Coveralls (under suit)
7. Disposable outer boot covers
8. Hard hat
9. Escape mask
10. Face shield

C. Selection

1. All criteria for air purifying respirator must be met (this is the most limiting factor).
2. The air contaminants, liquid splashes, or other direct contact will not adversely affect (be absorbed through any exposed skin).

3. Type of air contaminants and their concentrations are known.

3. Level B

A. Level B affords the wearer the highest level of protection against respiratory hazards but a lesser degree of protection for the eyes and skin. The main difference between in Level B and Level C is the use of a self-contained breathing apparatus (SCBA) to protect the wearers respiratory tract rather than an APR used in Level C. The EPA requires at least Level B protection on initial waste site entries, and then proper safety precautions have to be used. These would include, but not limited to: (a) approach from upwind, (b) no confined space entries, (c) use of monitors, etc.

B. Equipment needed

1. Positive pressure, full facepiece self-contained breathing apparatus (SCBA) or positive pressure airline respirator with escape SCBA (NIOSH approved)
2. Hooded chemical resistant clothing (one or two piece, reusable or disposable)
3. Chemical resistant outer gloves
4. Chemical resistant inner gloves
5. Chemical resistant boots (steel toe and shank)

Optional Equipment

6. Coveralls
7. Outer disposable boot covers
8. Hard hat
9. Face shield

C. Selection

1. The type and atmospheric concentration of substances have been identified and a high level of respiratory protection is needed but a lesser degree of skin protection is required.
2. The atmosphere contains less than 19.5% oxygen.
3. Atmospheres containing IDLH atmospheres of specific substances that present a severe inhalation hazard rather than a skin absorption hazard.
4. The presence of incompletely identified vapors and gases but these gases and vapors are not suspected to have chemicals harmful to the skin.

4. Level A

A. This is the highest level of protection offered to the wearer in all three areas: eyes, skin, and respiratory tract. There are three main types: (a) those with SCBA worn inside the suit, (b) those with the SCBA worn outside the suit; and (c) those using an airline respirator. Each of these has limitations:

1. SCBA worn inside the suit
   - Extra weight
   - Limited air supply
2. SCBA worn outside the suit
   - Extra weight
   - Limited air supply
   - Contamination of the (SCBA)
   - No positive pressure inside the suit
3. Airline respirator
   - Reduced mobility
   - User must carry escape pack

   The totally encapsulating suit is the major difference from Level B, thus offering the skin protection needed.

B. Equipment needed

1. Positive pressure full face piece SCBA or positive pressure air line respirator with an escape SCBA (NIOSH approved)
2. Totally encapsulating chemical protective suit
3. Outer chemical resistant gloves
4. Inner chemical resistant gloves
5. Boots, chemical resistant, steel toe and shank

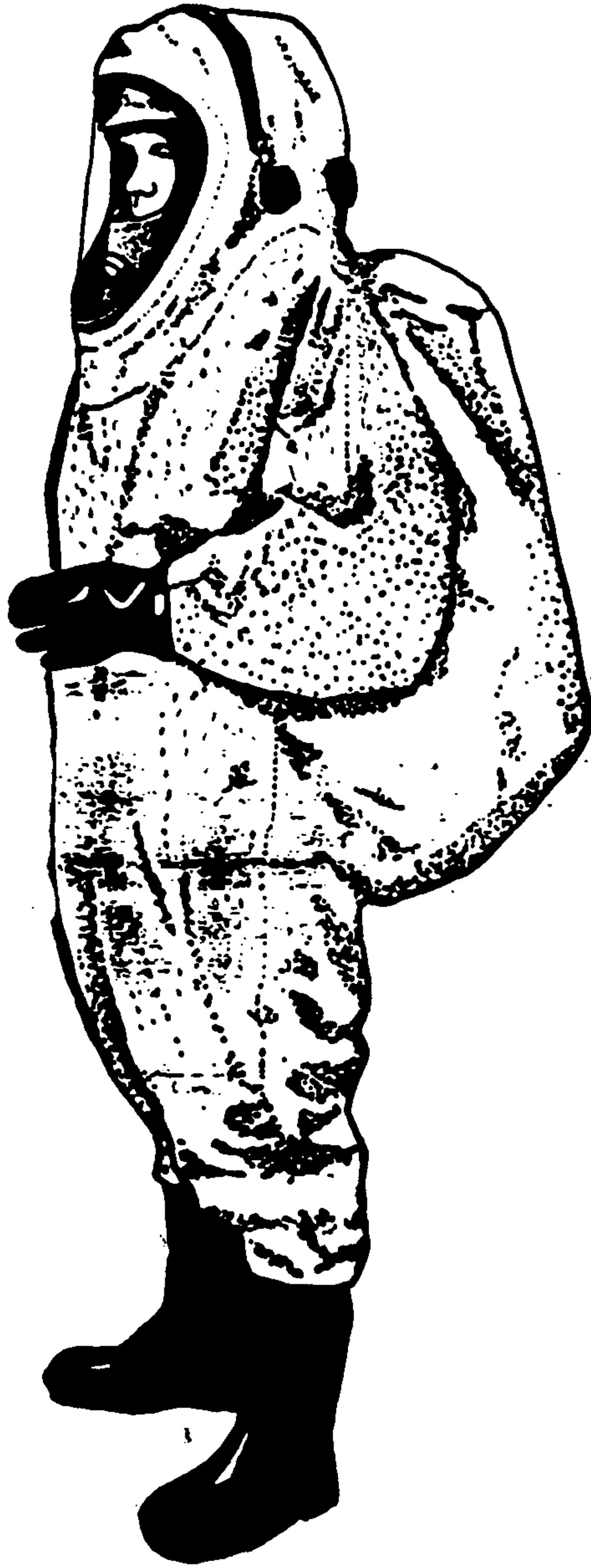
Optional Equipment

6. Coveralls
7. Long cotton underwear
8. Hard hat (under suit)
9. Disposable boot and glove covers

C. Selection

1. Levels of hazardous substances identified; and require the highest amount of protection for the skin, eyes, and respiratory tract.
2. Suspected presence of materials with the capability of absorption through the skin.
3. Operations in confined spaces or poorly ventilated areas where conditions of hazards are unknown.

LEVEL A



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LEVEL B

LEVEL C

LEVEL D

Looking at the different levels of protection one can see that the protection offered increases as the letter designating the coverage decreases. In the past responders used the saying, "Level A all the way" to keep from having to choose the appropriate level needed. This type approach to protective clothing can cause problems. When chemical protection increases, the ability to do physical work decreases. A job requires 10 minutes in Level C protection may take up to an hour in Level A.

With increased time of exposure to a product the potential of something going wrong with the suit or the potential for changes in the incident (such as chemical reactions, fires, or explosions) also increase. Therefore, the responder should choose the appropriate level of protection but not overkill the incident, with regards to protective clothing.

Standard fire fighting gear was not mentioned for the simple reason that it is not chemical protective clothing. Depending on the reference used, one may find standard firefighting gear classified as Level B through Level D protection firefighters gear does not meet the criteria for any of these levels of protection, yet such gear affords some limited protection to the responder. Such clothing should never be used to accomplish a level of chemical protection. This gear (turnout gear) is designed to be used in fire fighting, and does a very good job in that area. It is not a "protect all" in every emergency. Its limitations should be reviewed and understood before the clothing is ever brought to the scene of a hazardous materials emergency.

In summary two things have to be considered when choosing the level of protection needed:

1. The Hazard - What chemical or chemicals are present and what are their concentrations?
2. The Risk - What is the potential for the wearer to come in contact with the material? Someone doing monitoring of an area may not need nearly as much protection as someone who will actually be patching or plugging leaks.

II. Suit Designs and Materials

As explained earlier, there are several types of suits in each level of protection. The responder must choose which is the best for a particular situation. The design of suits varies, but basic requirements should be considered before one purchases of or uses any suit.

A. Suit performance requirements

1. Durability - Simply how strong is the material? What is the material's ability to resist

tears, punctures, and abrasions?

2. Flexibility - This will directly affect the workers ability to move and range of motion. The material must be able to bend or flex if needed.

3. Temperature Resistance - Many materials will lose their flexibility in extremely cold temperatures and lose their chemical resistance in hot temperatures. Both ends of the temperature scale should be considered before selecting a suit.

4. Service life - How long will the suit last? Many factors come into play in this area: Proper storage, chemical exposure, use in training all affect the life of the suit and should be considered during its selection and purchase.

5. Cleanability - The ease of decontamination after an exposure varies greatly with different

materials. In the more expensive suits, cleanability must be addressed beforehand, or one may find himself throwing away a suit that costs several thousand dollars.

6. Design - How the suit is constructed is of extreme importance:

    1. Fully encapsulating or non-encapsulating
    2. One, two, or three piece
    3. Hoods, facepieces, gloves, and boots (attached or unattached) (are they made of the same material as the suit, if not what material)
    4. Location of zippers, buttons, flaps, and seams (front, side, or back)
    5. Pockets, cloth collars, and velcro straps.
    6. Exhalation valves or vent ports.
    7. Compatible with proper respiratory protection to be used.
    8. Size - depending on the number of personnel that may have to use the suit; a proper fit allowd the wearer greater ease in movement.

9. Color - a highly visible light colored material is desired if possible. Dark colors absorb heat rather than reflect it, it thereby causing the wearer additional stress.

10. Cost - Depending on the nature of the materials that one may come in contact with, a less expensive limited use suit may provide adequate protection to the wearer.

11. Chemical resistance - the ability of a material to withstand chemical and physical change.

B. Chemical Resistance

There is no one suit suitable for all hazardous materials emergencies. The same holds true for materials of suits. Some offer good protection against a wide range of chemicals, but none is good for all.

Three main areas to check regarding the chemical resistance of a suit are (a) resistance to penetration, (b) degradation, and (c) permeation.

Each of these properties must be examined individually because one is not always in direct relation to the other. A particular suit may have an excellent degradation rating, whereas its permeation rate may be totally unacceptable to the responder.

1. Penetration - The movement of chemicals through some type of opening in the suit. This may be imperfections in the material, stitched seams, zippers, or any place where the surface has any openings, such as pinholes, etc.

2. Degradation - The breakdown of the material caused by chemical contact may be evidenced by some type of physical change in the material. Degradation may cause the material to shrink, swell, become soft and pliable, or brittle. When such changes occur, the chemical resistance of the material is obviously greatly reduced.

3. Permeation - the ability of a chemical to move through an intact piece of material on a molecular level. Permeation is not caused by imperfections in the suit. The materials used in protective clothing resist chemicals in different ways, however none is capable of providing a complete impermeable barrier against all chemicals. Permeation is measured in two ways: (a) the permeation rate and (b) the breakthrough time.

a. Breakthrough time - the amount of time it takes for a chemical on one side of the material to show up on the other side.

b. Permeation rate - the rate at which the chemical will travel through the material once it has broken through (e.g., 5 drops an hour).

All three of these chemical resistance properties play an important role in the overall effectiveness of the suit. These factors should be examined closely by the users to determine which suit and material best serves their purpose. This information should be provided to you by the manufacturer usually in a chart or graph. The chart or graph shows the compatibility of the suit to a wide range of chemicals which may be encountered.

C. Procedures for the chemical protective clothing

Proper procedures should be followed to ensure that the chemical protective clothing to be worn on the scene of an emergency, is capable of adequately protecting the responder. These procedures change somewhat, depending on the particular suit that is to be used but all follow certain guidelines. Which follow:

1. Testing -
   - Visual inspection - spread suit on a flat surface and inspect for the following
     - Abrasions, cuts, holes, or tears
     - Seams for separations or holes
     - Zippers, buttons, and flaps for proper closure
     - Discoloration, rough surfaces, cracks, or a rough feeling could be evidence of chemical attack or incomplete decontamination
     - Exhalation valves for proper function
     - Facepiece for cuts, abrasions, and adequate seal to suit
     - Condition of gloves, boots and attaching devices
   - Pressure test - pressure test procedures vary from suit to suit; all must meet certain criteria.
     - Test pressure should be at least 2 inches water gauge.
     - Duration should be at least 3 minutes.
     - Pressure drop should not be over 20% during test.

- Light test - a quick and easy way to inspect a suit is to run a flashlight inside the suit to look for pinpoints of light from outside the suit.

2. Log for suit - each suit should have its own log showing at least the following:
   - Manufacture date
   - Date put into service
   - Periodic test results
   - Any repairs done
   - Any exposures
   - Decontamination procedures used after an exposure
3. Maintenance and storage - The life of a suit can be greatly increased by proper maintenance and storage procedures. The following steps should be adhered to.
   - Store suit with as few bends and folds as possible
   - Protect from extreme heat or cold while in storage
   - Proper and thorough decontamination procedures after any exposure
   - Have manufacture repair any problems with suit other than very minor problems

- Have manufacture periodically test suit to confirm your test results

III. Additional equipment available to the responder

1. High temperature clothing -

Chemical protective clothing is not designed to withstand extreme temperatures such as those caused by a fire. Therefore, some other protection must be worn over or in place of chemical protective clothing depending on the situation. These suits in some cases are compatible and can be worn over an encapsulated chemical suit such as some "aluminized approach suits", but such suits withstand only a very short exposure to radiant temperatures up to and over 1500°F.

Suits thought of as fire entry suits are extremely bulky and are very hard to adapt to a situation needing the total encapsulating suit. However suits can withstand temperatures up to 1500°F while totally engulfed in flames for a short duration of time and provide much needed protection from flash fires for the responders. This protection is not available through normal chemical protective clothing.

2. Cooling devices

While working in chemical protective clothing the wearer can become extremely hot (especially in Level A equipment). For this reason, personal cooling devices have been developed which though limited in their use, can provide protection from heat related problems yet not eliminate them altogether. Different type suits are on the market but all seem to follow a few basic designs.

1. Compressed air systems - These devices use air from a compressor or supplied air system to help cool the wearer. Cool dry air is pumped through tubes to areas of the body (usually ankles, wrists, and head) to aid the evaporation of perspiration and cools the wearer.
2. Ice vest or jackets - A vest or jacket containing ice, is worn under the suit to cool the wearer; can sometimes last up to an hour, but the ice melting creates extra weight for the wearer-- without the once provided cooling.
3. Circulating systems - These systems circulate water or a water/alcohol mixture to help cool the wearer and may be hooked to an outside supply or contained within the suit. Water is circulated around the body in small tubes, then chilled by some means to be recirculated. These systems can last quite a while, but additional weight encountered has been found to be not worth the effort by many responders.

IV. Limitations encountered by the wearer of chemical protective clothing.

Two main problems often encountered by wearing chemical protective clothing; (a) the physical and physiological stress and (b) the heat related problems.

A. Physical/physiological problems

Many factors come into play to cause these problems. The more that can be addressed and alleviated the better the responder is able to handle the emergency. Some of the factors that influence physical or physiological stress:

1. Working in extreme weather conditions - Hazardous Materials emergencies are more prone to happen in extreme hot or cold temperatures and in storms. The outside factors influencing the materials and the handlers of the materials increase the chances of an accident.
2. Working in close proximity to hazardous materials - Knowing that in the event of a suit failure or similar emergency severe harm may come to the responder, adds to the stress on the wearer.
3. Working in life threatening situations - not only to the responder but to the victims and surrounding public.

4. Wearing chemical protective clothing -
   - additional weight
   - reduced visibility
   - limited mobility
   - sometimes claustrophobia
   - limited communications

Ways to alleviate some of the stress involved:

1. Having only well trained personnel wear the suits helps create confidence in the suits capabilities
2. Practicing with this equipment allows the wearer to; (a) become comfortable in its use and (b) concentrate on the job--not the suit.
3. Monitoring personnel with physical sprior to their exposure to any hazardous materials, periodically while working in this field, at the termination of job duties requiring a potential for exposure, and after any symptoms of exposure are encountered.
4. Employing physically fit personnel with the ability to overcome stress, e.g., additional weight, extreme temperatures.
5. Using the buddy system anyone wearing this type of equipment should always have some one to back him up in the event of an emergency.

Knowing that someone is there to help you will help ease ones mind during emergencies.

6. Standard operating procedures (SOPs) should be written which show the wearer that problems which may arise have been addressed ahead of time. Proper procedures have been developed and can be implemented in case of an emergency.

2. Heat Related Emergencies

Working in chemical protective clothing may cause an additional amount of heat, above that of the ambient temperature, to be put on the responder. Aggravating many problems ranging from minor to very serious. Some types of heat stress, their signs and symptoms are listed below:

a. Heat rash - a rash that could result from continuous exposure to heat or humid air.

b. Heat cramps - Caused by inadequate replacement of electrolyte in the body lost by profuse sweating. Signs and symptoms are:

    a. Muscle spasms

    b. Pain in the hands, feet, and abdomen.

c. Heat exhaustion - occurs from additional stress put on body organs due to dehydration.

Signs and symptoms are:

a. Pale, cool, moist skin

b. Heavy sweating

c. Dizziness

d. Nausea

e. Fainting

d. Heat stroke - The most serious form of heat stress. The body's temperature regulation functions fail and the body temperature rises to critical levels. Immediate medical attention by trained personnel must be administered, or serious injury or death may occur. Signs and symptoms are:

a. Red, hot, usually dry skin

b. Lack of, or reduced, perspiration

c. Nausea

d. Dizziness and confusion

e. Strong, rapid pulse

f. Coma

Constant monitoring of these personnel along with adequate rest periods must be adhered to. Some of the areas that must be monitored are the heart rate, temperature, and weight of the persons in the suits.

1. Heart rate - when the heart rate exceeds 110 beats per minute at the beginning of a rest period some

type of work schedule adjustment must be made. Shorter work periods or longer rest periods should be used.

2. Temperature - When the temperature of a worker exceeds 99.6°F at the beginning of the rest period, a work schedule adjustment must be made. Either shorter work periods or longer rest periods must be used. If a worker's temperature exceeds 100.6°F, do not allow him to work in chemical protective clothing.

3. Weight - checking body weight during operations will give information on body water loss. If body weight drops by 1.5%, work should be discontinued for the day.

The frequency of this monitoring depends on the ambient temperature and the physical work being done. Any time ambient temperatures reach 70°F, regardless of the work being done, medical monitoring of personnel for heat related problems should be implemented.

V. Summary

One of the most important areas of emergency response to hazardous materials incidents is the issue of proper protective clothing. The responder must choose the proper level of protection as well as the material compatability. As the incident progresses, the protective clothing must be continually evaluated and changed as dictated by the incident. Protective clothing, whether level A or level C, presents a certain amount of stress for the responder requiring a good medical monitoring program. A good selection process, continual evaluation, medical monitoring, and proper suit maintenance and care, will protect the responder from chemical exposure.

SITE CONTROL - WORK ZONES

I. Introduction

The activities required during response or the physical and chemical properties of a hazardous substance may contribute to the unwanted movement of contaminants from the site to uncontaminated areas. The ambient conditions and site characteristics may pose a contamination threat. In order to minimize the transfer of hazardous substances from a site, contamination control procedures are needed. Several methods are used: (a) containment or confinement of the product or (b) by establishing site work zones and removing contaminants from people and equipment. A discussion of guidelines for work zones follow. Work zones with controlled access and egress points should be established so that uninformed citizens, sightseers, and other emergency responders can not enter the danger area.

II. Site Control

One way to reduce the possibility of exposure is by controlling the site. The responder's primary goal is to save lives. This goal can be accomplished by (a) not allowing contact with any contaminants present or (b) by preventing the removal of contaminants on personnel or equipment leaving the site. These goals can be achieved a number of ways:

- Setting up site security to exclude unnecessary personnel from the general area
- Minimizing the number of personnel and equipment on-site consistent with effective operations

- Establishing work zones within the site
- Establishing control points to regulate access to work zones
- Conducting operations in a manner to reduce the exposure of personnel and equipment and to eliminate the potential for airborne dispersion
- Implementing decontamination procedures

III. Work Zones

One method of preventing or reducing the migration of contaminants is to establish zones at the site and control the flow of product, people, and tools (machinery) in or out. These zones are controlled by entrance and egress points. Three contiguous zones are recommended:

- Zone 1: Exclusion zone (Hot zone)
- Zone 2: Contamination reduction zone (Warm zone)
- Zone 3: Support zone (Cold zone)

A. Zone 1: Exclusion Zone

The exclusion zone, the innermost area, is the physical area where contamination does, or could, occur. Entry and exit check stations must be established at the edge of the Exclusion Zone to regulate the flow of personnel and equipment into and out of the zone and to verify that the safety procedures established to enter and exit are followed. All people entering the exclusion zone must wear the prescribed levels of protection and all people exiting the exclusion zone must go through decontamination procedures.

Many factors play a role in establishing the outer boundary of the exclusion zone (hotline). Once the hotline has been determined, it should be physically secured, fenced, or well-defined. During the incident, the boundary should be evaluated and adjusted if the situation dictates. Some of the determining factors are:

- Initial visual survey of site to locate hazardous material
- Where drainage, leachate or spilled material will go
- Where any discoloration is visible
- Initial site survey, including monitoring instrument readings (combustible vapors, radiation particulates in air)
- Whether explosion or fire hazard exist

The establishment of this zone is arbitrary but should be based on factual knowledge of the incident site and the products physical and chemical properties along with experience and judgment.

1. Subareas within the exclusion zone

The required level of protection must be worn within the exclusion zone by all personnel. The level of protection is determined by the measured concentration of substances in air, potential for contamination, and the known or suspected presence of toxic substance. Often subareas are specified and should be conspicuously marked as to the level of protection needed A,B, or C. The job assignment or type of work to be done within the zone may dictate the level of protection. When acceptable different levels of protection, could be utilized allowing more flexibility, less stress, and being less costly, but still maintaining a high degree of safety.

B. Zone 2: Contamination reduction zone

The contamination reduction zone acts as a buffer between the exclusion zone (contaminated) and the support zone (uncontaminated). Zone 2 is a transition area for personnel and equipment who have been exposed, so they can be decontaminated. It provides additional assurance that the physical transfer of contaminated substances on people or equipment is limited through a combination of decontamination, zone restrictions, and work functions.

When first set up, the contamination reduction zone is considered a non-contaminated area. In order to cross from the contamination reduction zone to the exclusion zone and back, personnel and equipment must pass through contamination reduction corridors. These corridors consist of an appropriate number of decontamination stations. Usually there is one established for people and one for heavy equipment. Depending on the size of the operation, two or more contamination reduction corridors may be utilized. As operations proceed, the area around the decontamination station may become contaminated, but to a much lesser degree than the exclusion zone. The amounts of contaminants should decrease from the hotline to the support zone due to the decontamination procedures. A general rule of thumb is that personnel can operate at one level of protection lower in this zone than the level in the exclusion zone. In order to cross the line from the contamination reduction zone to the support zone, the responder has to utilize a control check point and remove all protective clothing or equipment and leave it in the contamination reduction zone.

C. Zone 3: Support zone

The support zone, the outermost part of the site, is considered a non-contaminated or clean area. Normal work uniforms are appropriate dress within this zone. Support equipment, command post, resources and extra man power are located in the area. The support zone is also a restricted area, admitting only authorized response personnel. Due to no protection from contaminants within this zone, the potentially contaminated personnel clothing, equipment and samples are <u>not</u> permitted but are left in the contamination reduction zone. In order for personnel, equipment, and samples to cross between the contamination reduction zone and the support zone, it must be decontaminated.

The location of the command post and other support facilities in the support zone depends on a number of factors, including but not limited to:

- Accessibility: topography; open space available; location of highways; railroad tracks; or other physical limitations.
- Wind direction: preferably the support facilities will be located upwind and up hill of the exclusion zone. Shifts in the wind and other changing conditions must be considered.
- Resources: adequate roads, power lines, water, food, and shelter should be available or in close proximity to the site.

IV. Zone dimensions

The distance between the hotline, contamination control lines, and command post, and the size and shape of each zone has to be based on conditions specific to each site. Judgment and experience are needed to assure that the distance between zone boundaries is large enough to allow room for necessary operations, provide adequate distances to prevent the spread of contaminants, and eliminate the possibility of injury due to explosions or fires. Operations should be monitored in all zones periodically and boundaries and site safety plans reevaluated. The following criteria should be considered in establishing area dimensions and zone boundaries:

- Physical and topographical features of the site
- Weather conditions
- Field laboratory measurements of air contaminants and environmental samples
- Air dispersion calculations
- Physical, chemical, toxicological, and other characteristics of the substances present
- Cleanup activities required
- Potential for fire or explosion
- Size of area needed to conduct operations
- Decontamination procedures
- Potential for exposure
- Proximity to residential or industrial areas

V. Summary

The three zone system, access control points, and enacting decontamination procedures provide a reasonable assurance against the transfer of contaminating substances. The site control system is adaptable - it can be scaled up or down as the incident dictates. The zone lines need to be established and strictly adhered to via a strong safety plan and standard operating procedure. Remember to monitor the three zones and continually update and reevaluate the operating procedure.

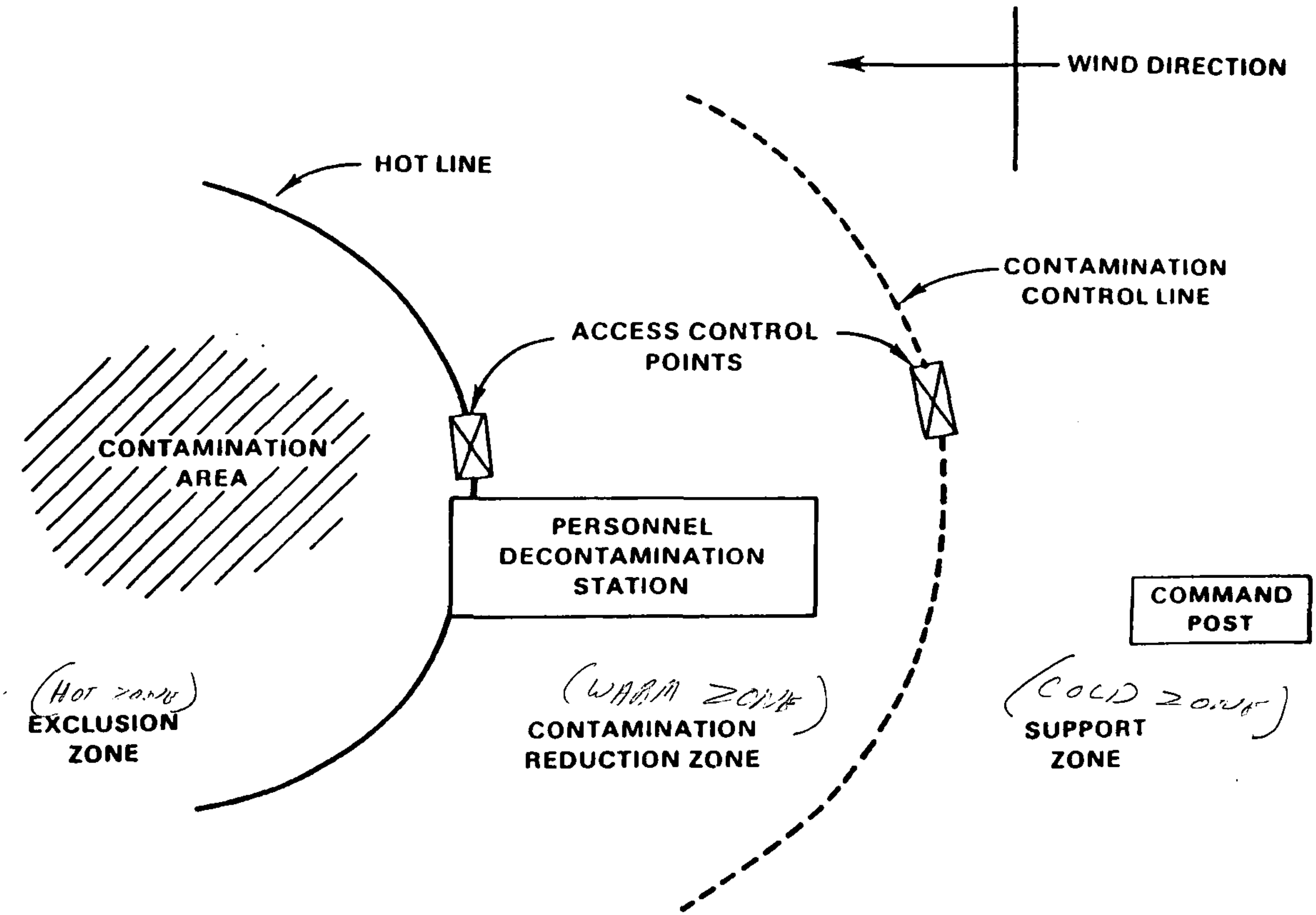

DIAGRAM OF SITE WORK ZONES

EPA ENVIRONMENTAL RESPONSE TEAM

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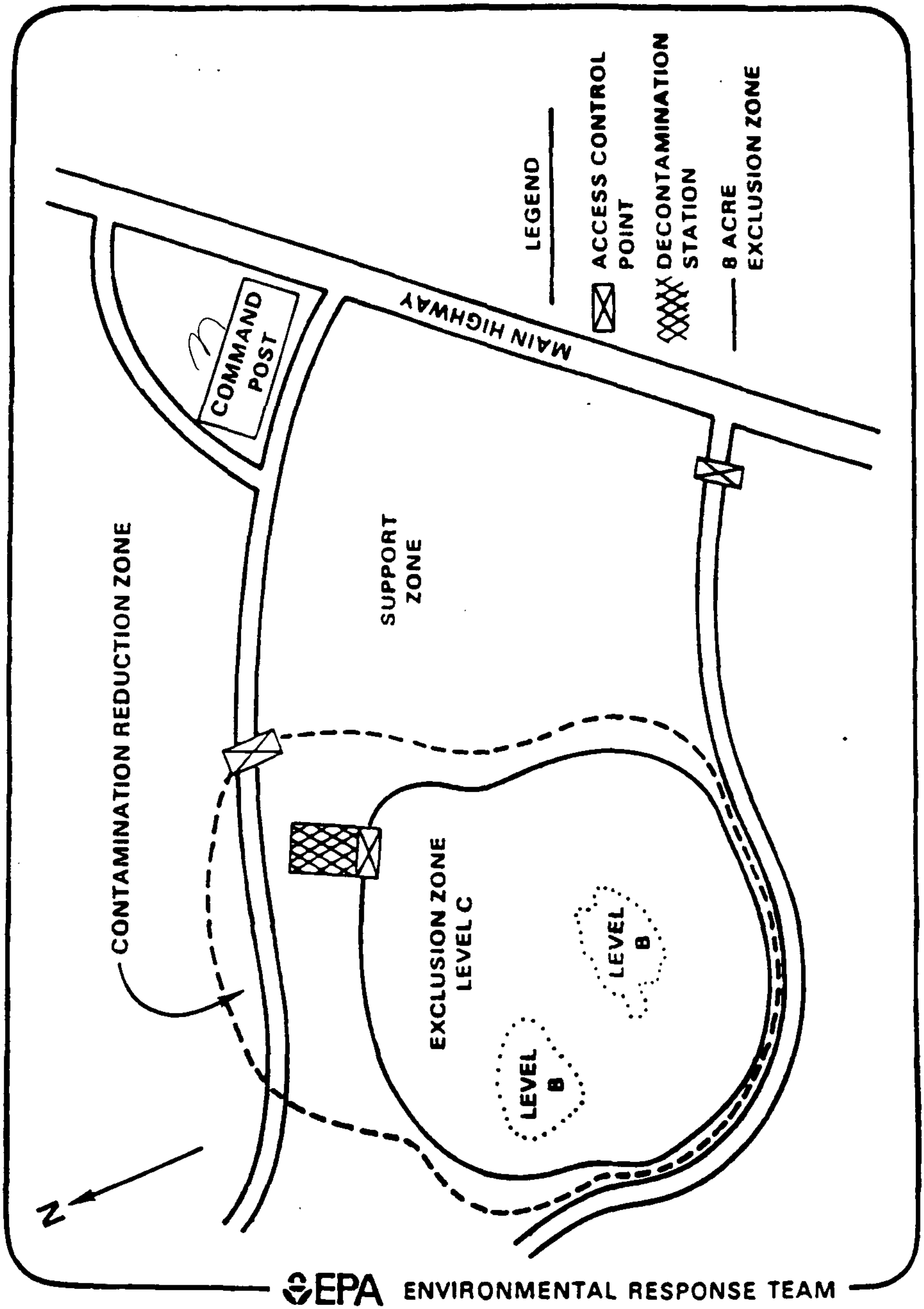


SITE CONTROL - DECONTAMINATION

I. Introduction

Emergency responders to hazardous materials incidents probably have a greater chance of coming in contact with materials than other groups. The emergency responder's job is to save lives and protect property and the environment, usually by containing the materials, i.e., plugging, patching, damming etc. In order to accomplish these tasks, he may become contaminated in a number of ways. Protective clothing and self contained breathing apparatus help prevent the wearer from becoming contaminated or inhaling the substance. Good work practices help reduce contamination to protective clothing, instruments, and equipment. Even with these safeguards contamination may occur.

During the removal of contaminated clothing, personnel may contact contaminants or inhale them. To prevent these occurrences, methods to reduce contamination and decontamination procedures must be developed and established before any one enters a site and must continue (modify when necessary) throughout the incident.

Decontamination consists of physically removing the contaminants or changing their chemical nature to innocuous substances and containing the runoff to be disposed of properly. How extensive decontamination procedure must be depends on a number of factors, the most important being the type of contaminants involved. The more harmful the contaminant, the more extensive and thorough decontamination must be.

Throughout this training, the incident usually dictates the response. This is true for decontamination, the correct method of doffing personnel protective equipment, and the use of site work zones minimizes cross contamination from protective clothing to wearer, equipment to personnel, and from one area to another. The following are some general guidelines and methods for decontamination. The exact procedure to use must be determined after thoroughly evaluating a number of options specific to the incident.

II. Preliminary considerations

A. Initial Planning

The initial decontamination plan assumes all personnel and equipment leaving the exclusion zone (area of potential contamination) are grossly contaminated. A system of sequential stations is setup for personnel decontamination to wash and rinse, at least once, all the protective equipment worn. The responder then systematically removes the protective equipment, starting at the first station with the most heavily contaminated item and progressing to the last station with the least contaminated article. Each procedure requires a separate station. The tools are dropped at a "tool drop point" prior to entering the contamination reduction zone.

To reduce the spread of contamination during the washing/doffing, the decontamination stations should be a minimum of three feet apart. Ideally, contamination should decrease as a person moves from one station to another. This should be checked using monitoring equipment, or sample test periodically, if there is any doubt.

Based on a worst-case scenario, the initial decontamination plan assumes no information is available concerning the incident. The site is then evaluated looking for specific conditions, such as:

- Type of contaminant (physical state, chemical properties)
- The amount of contamination
- Levels of protection required
- Type of Protective clothing worn
- Type of equipment needed to accomplish the work task

The initial decontamination plan is modified as the incident progresses. Stations may be added or reduced, for instance; the initial plan may require wash and rinse of protective clothing. If disposable garments are worn, the wash/rinse station could be omitted. All changes in the decontamination procedure must go through the command post and be noted in the site safety plan.

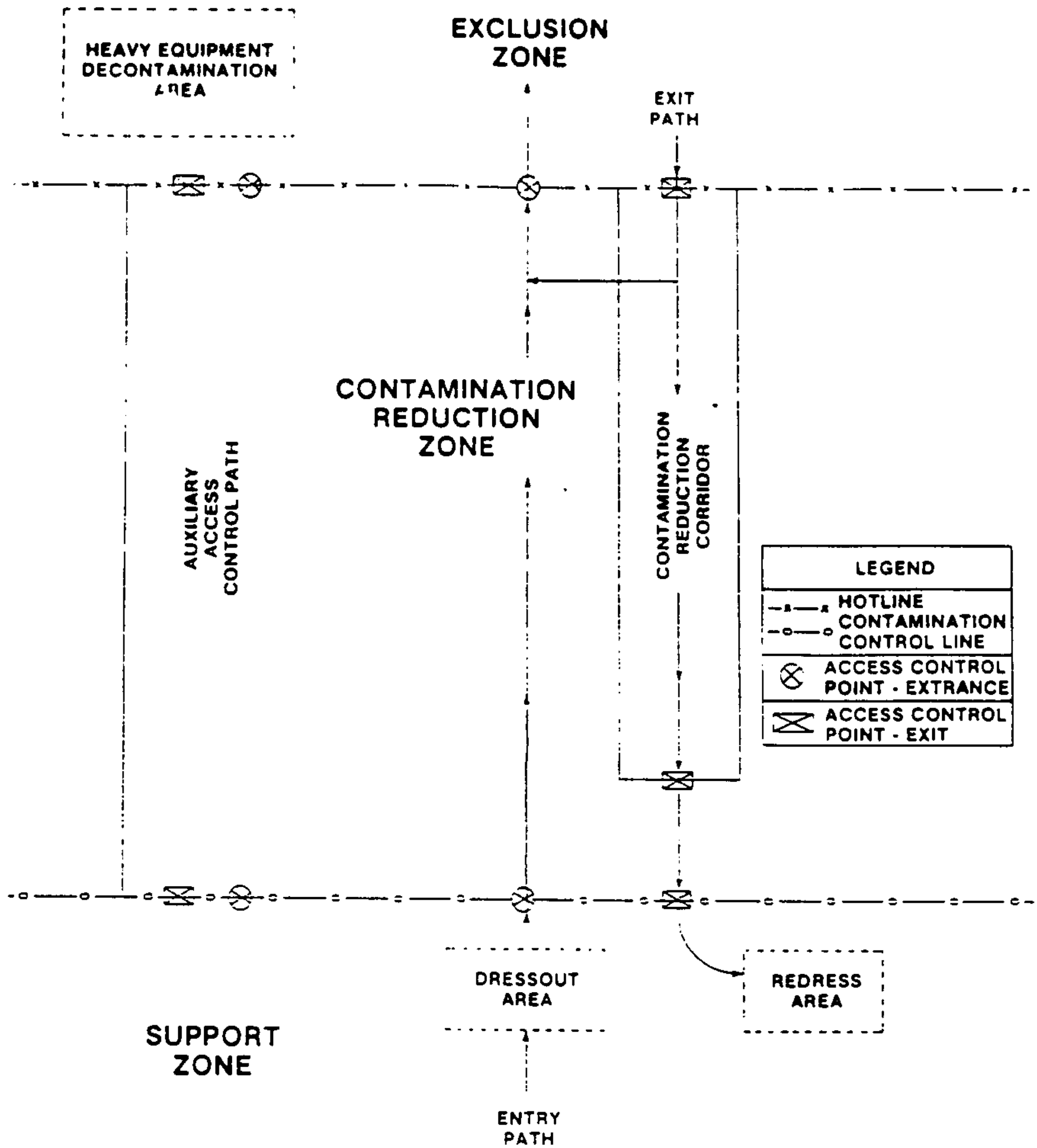
B. Contamination Reduction Corridor

The contamination reduction corridor (CRC) is an area designated within the contamination reduction zone (warm zone). The CRC controls egress points out of the exclusion zone and confines decontamination activities to a limited area. Overall size and dimensions of the corridor depend on the stations needed and the amount of space available at the site. A minimum of 75 feet by 15 feet is required for a full decontamination set-up. If at all possible, the corridor should be a straight path.

The CRC boundaries should be conspicuously marked with control of personnel entering or exiting. The beginning of the CRC is the hotline, the boundary between the exclusion zone and the contamination reduction zone. Everyone exiting the exclusion zone <u>must</u> go through the contamination reduction zone. Everyone in the CRC should be wearing the level of protection designated for the decontamination crew. The CRC is assumed contaminated and must be treated as such. Another corridor may be needed for heavy equipment.

The activities within the corridor are confined to decontamination. Different areas are set aside for decontamination of personnel, portable field equipment, removed clothing, etc. These areas should be clearly marked and personnel working within are required to wear appropriate levels of protection. The maintenance of clothing, SCBAs, monitoring equipment, etc. is done outside the contamination reduction corridor. Personnel don their protective equipment away from the CRC and enter the exclusive zone through a separate access control point at the hotline.

The following is an example of a contamination reduction zone showing a contamination reduction corridor.



CONTAMINATION REDUCTION ZONE LAYOUT

III. Extent of decontamination required

A. Modifications of initial plan

An incident changes causing the responder to reassess the situation periodically. The original decontamination plan must also be adapted to the conditions found at an incident. A number of factors affect the decontamination plan.

1. Type of contaminant

All substances have specific chemical and physical properties which create hazards to a responder. The amount of personnel decontamination needed depends on the effects the contaminants have on the body. If the substance is known to be highly toxic or skin destructive, a full decontamination procedure should be followed. If the substance poses a lesser threat, the procedure can be down graded.

2. Amount of contamination

The amount of contamination on protective clothing and other objects is usually determined visually, but not always. If it appears grossly contaminated, a thorough decontamination is required. Large quantities of material remaining on protective clothing for any extended period of time may degrade or permeate it. Higher concentrations and prolonged contact of liquid contaminates increases the potential for suit breakdown. Gross amounts of contaminates also increase the possibility of personnel contamination. Swipe tests may help determine the type and quantity of surface contaminants.

3. Level of protection

Different levels of protection pose certain problems with decontamination. The level of protection and specific pieces of equipment, used will determine on a preliminary basis, the layout of the contamination reduction zone. Clothing variations and different levels of protection may require adding or deleting stations in the original decontamination procedure.

4. Work function

The work each person does determines the potential for contact with hazardous materials. This may effect the layout of the decontamination line. For example, photographers, operators of air monitoring (with no reading) or others in the exclusion zone that have no contact with contaminants may not need to have their garment washed and rinsed. If there is a possibility of contact, then a decontamination is required.

5. Location of contamination

Contaminants on or around the upper body pose a greater risk to the worker because volatile compounds may generate hazardous breathing concentrations for the worker and for the decontamination personnel. The risk of skin contact increases when doffing the upper part of the clothing.

6. Reason for leaving site

The reason for leaving the exclusion zone determines the need and extent of decontamination. A worker leaving to get a new air cylinder will require a lesser degree of decontamination, than the responder leaving the contamination reduction zone for a break, lunch or at the end of the day must be thoroughly decontaminated.

B. Effectiveness of decontamination

The responder may or may not be able to visually determine how effective decontamination is. Discoloration, stains, and corrosive effects may indicate contaminants have not been removed but in fact have. Visual inspection usually reveals surface contamination and not permeation into clothing or tools. Simply put many contaminants can not be seen.

A method used for determining the presence of contamination is the swipe test. Cloth or paper patches, swipes, - are wiped over predetermined surfaces of the object and analyzed in a laboratory. The inner and outer surface of protective clothing should be swipe tested. A positive test on both swipes would indicate decontamination was not thorough and that permeation had occurred. Permeation test on the garment requires a laboratory analysis of a piece of the material. The problem in swipe and permeation testing is often the lack of immediate results. However, the results from these test along with visual observation can help evaluate the effectiveness of decontamination.

Many times, depending on the materials involved, chemical protective clothing may have to be discarded. If a positive determination cannot be made whether equipment is contaminant free, then it must be disposed of as hazardous waste.

C. Equipment

Decontamination equipment, materials and supplies are generally selected based on availability. Other considerations are ease of equipment decontamination or disposability. The responder needs to be practical as most supplies can be easily obtained. Brushes are used to remove contaminants. Water in buckets or garden sprayers are used for rinsing. Long galvanized tubs or stock tanks along with children's wading pools can provide a wash basin and hold runoff. Large garbage cans lined with plastic bags can be used for contaminated clothing, equipment or samples. Metal or plastic drums may be needed to store contaminated liquids and rinse solutions. Paper and cloth towels are a necessity. A word of caution--decontamination materials must be compatible with the contaminants.

D. Decontamination solution.

Scrubbing personnel protective equipment, and tools with a detergent - water solution and soft bristle brush followed by rinsing with copious amounts of water is a relatively safe procedure. However, the contaminant must be identified. Another option is using a chemical decontaminating solution which changes the contaminant into a less harmful substance (degradation). The appropriate decontamination solution must be selected in consultation with an experienced chemist. Degradation is not normally recommended.

E. Establishment of procedure

Decontamination procedures must be established. All personnel requiring decontamination must be given precise instructions and practice. Compliance must be frequently checked. Time runs should be made to allow the worker wearing an SCBA time to complete decontamination and still have breathable air. The effectiveness of the decontamination procedure also needs to be checked.

IV. Decontamination during medical emergencies

A. Basic considerations

Managing medical emergencies should be part of planning for incident response. Planning during a medical emergency should include:

- Response team members should be trained in advanced first aid and emergency lifesaving methods.
- Prior arrangements with medical facilities for transportation and treatment of injured and exposure to chemicals.
- Providing consultation with toxicologists and other medical specialists.
- Specialized equipment on hand, for example, emergency eye washes, showers, first aid kits, blankets, stretcher, resuscitatoron and if possible an EMT on standby.

A protocol should be established for decontaminating personnel with medical problems or injuries. The decontamination procedure may aggravate or cause more serious health effects. If life threatening injuries are received, prompt life saving first aid and medical treatment should be administered as soon as possible concurrently with decontamination procedures. The toxicity of the contaminant will dictate the action. Should the product be so toxic as to cause death or serious injury to the EMT the decontamination must be completed first. If the toxicity is not so critical then first aid procedures can be started prior to decontamination. If a victim is transported prior to total decontamination, response personnel should advise the medical facility on decontamination.

B. Physical injury

Depending on the seriousness of the injury, the victim may be treated at the site or transported to a medical facility. The range of injuries can be as simple as a sprain to a compound fracture. Life saving care should begin immediately without considering decontamination. The exception is if the contaminant is known to be extremely toxic or corrosive which could cause severe injury or loss of life.

Respirators and backpack assemblies must always be removed (open airway). Outer garments can be removed if the removal does not cause delays, interfere with treatment, or aggravate the problem. Cut fully encapsulating suits or chemical resistant clothing away. Do not try to remove in normal manner. If the contaminated garment cannot be safely removed, the victim should be wrapped in plastic, rubber or blankets to help prevent contaminating the inside of the ambulance or medical personnel. Outside garments are then removed at the medical facility. The medical personnel should be advised of the contamination problem as soon as possible, prior to arrival. To handle minor medical problems or injuries, the normal decontamination procedure should be followed.

C. Heat stress

Heat related illnesses consist of heat fatigue, heat cramps, and heat stroke. These should not be taken lightly. Heat stroke, the most serious, requires prompt treatment or irreversible damage or death may occur. The other heat related illnesses can quickly lead to heat stroke and require prompt attention. Protective clothing may have to be removed. Unless obviously contaminated, decontamination should be minimized and treatment began immediately.

D. Chemical exposure

Exposure to chemicals can be divided into two categories:

- Injuries from direct contact, such as acid burns or inhalation of toxic chemicals
- Potential injury due to gross contamination on clothing or equipment

Inhaled contamination can only be treated by a qualified physician. Contamination on the skin or in the eyes must be treated immediately. First aid procedures to counteract the substances effect usually calls for flooding the affected area with water. The responder should be aware that water may cause a reaction with the contaminant.

Grossly contaminated protective clothing should be washed off quickly and carefully removed. The contaminants may be transferred to emergency personnel. The exception is if severe medical problems which could cause serious injury or death exist. Prudent first-aid measures combined with common sense will be sufficient in most cases.

V. Protection of decontamination workers

Several factors determine the level of protection worn by workers in the contamination reduction zone.

- Expected or visible contamination of workers
- Type of contaminant and associated respiratory and skin hazards
- Total vapor/gas concentrations in the contamination reduction corridor
- Particulates and specific inorganic or organic vapors in the CRC
- Results of swipe tests

A. Level C use

Level C includes a full-face, canister type air purifying respirator, hard hat with face shield, chemical resistant boots and gloves, and protective clothing. The body covering recommended is chemical resistant overalls with an apron, or chemical resistant overalls and jacket.

The respirator should have a canister approved for filtering any specific known contaminants such as ammonia, organic vapors, acid gases, and particulates. A face shield is recommended for splash protection because some types of respirators may not provide this protection.

B. Level B use

When dealing with unknowns, highly volatile liquids, or highly toxic materials the decontamination worker should wear at least Level B protection. Level B protection includes SCBA, hard hat with face shield, chemical resistant gloves and boots, and protective clothing. The recommended clothing is chemical-resistant overalls, jacket and a rubber apron. The rubber apron protects the SCBA harness assembly and regulator from contaminants.

IV. Decontamination of equipment

Sampling and monitoring equipment should be protected from contamination. Once contaminated, instruments are difficult to clean without damaging them. Sampling instruments usually become contaminated while monitoring instruments usually do not. Delicate instruments should be protected by a clean plastic bag. The bag is taped and secured around the instrument and small holes made for sample intake and exhaust.

A. Decontamination procedures

1. Sampling devices

Sampling devices require special cleaning. The nature of their work puts the device in contact with the substance. The physical and chemical properties of the substance will dictate clean up. Several references should be consulted. The EPA regional laboratory will also provide information.

2. Tools

Wooden tools and other porous materials are difficult to decontaminate because they absorb chemicals. They should be kept on site and handled only by protected workers. At the end of the response such tools should be disposed of properly.

3. Respirators

Personnel responsible for decontaminating respirators should be thoroughly trained in respirator maintenance. If contaminated certain parts, such as harness assembly and straps are difficult to decontaminate and may have to be disposed of as waste. Rubber components can be soaked in soap and water and scrubbed with a brush. Regulators are required to be maintained according to manufacturer's specifications.

4. Heavy equipment

Bulldozers, trucks, back-hoes, and other heavy equipment are difficult to decontaminate. Methods used: wash under high pressure; scrub with detergent and water solution under pressure; steam clean; or sand blast. Tires, tracks, scoops, and parts that come in direct contact with contaminants, should be closely scrutinized. Personnel performing the decontamination must be adequately protected from the dust, mist, or aerosols which may be created.

B. Sanitizing of personnel protection equipment

Respirators, SCBAs, reusable protective clothing, or any other personal item must be decontaminated before reuse, and also sanitized. Pieces of equipment can become soiled due to exhalation, perspiration, or body oils. The manufacturer instructions should be followed to sanitize the respirator mask. Reusable protective clothing should be washed decontamination.

C. Persistent contamination

Normal decontamination procedures may not remove the contaminants. A solvent may be needed to remove such materials from equipment if it does not destroy or degrade the protective material. A word of caution--solvents or neutralization should be a last resort and compatability must be ascertained. Disposable garments should be used if persistent chemicals are anticipated. Qualified laboratory personnel must test for persistent chemicals and perform the appropriate decontamination.

D. Disposal of contaminated material.

All materials and equipment used for decontamination must be disposed of properly. Clothing, tools, buckets, brushes, and all other equipment that is contaminated must be secured in drums or other containers and labeled. Contaminated wash and rinse solutions should be contained by using step-in-containers (child's wading pool, etc.). Spent solutions are transferred to containers which are labeled and disposed of properly along with other substances on site. Articles which have been through decontamination but may require further cleaning should be transported from the site in sealed containers such as plastic bags.

VII. Annexes

Annex 1, 2, and 3 describe basic decontamination procedures for a worker wearing Level A,B, or C protection. The basic decontamination lines (Situation 1), consisting of approximately nineteen stations, are almost identical except for changes necessitated by different protective clothing or respirators. The basic or full decontamination procedure can be changed to take into account differences in the extent of contamination, the accompanying changes in equipment worn, and other factors. The situations illustrate decontamination setups based on known or assumed conditions at an incident. Many other variations are possible.

Annex 4 describes a minimum layout for Level A personnel decontamination. The number of individual stations have been reduced. Because the decontamination equipment and amount of space required is less than previous procedures described, there is a much higher probability of cross contamination.

ANNEX 1

LEVEL A DECONTAMINATION

A. EQUIPMENT WORN

The full decontamination procedure outlined is for workers wearing Level A protection (with taped joints between gloves, boots, and suit) consisting of:

- Full encapsulating suit
- Self-contained breathing apparatus
- Hard hat (optional)
- Chemical-resistant, steel toe and shank boots
- Boot covers
- Inner and outer gloves

B. PROCEDURE FOR FULL DECONTAMINATION

Station 1: Segregated Equipment Drop

Deposit equipment used on-site (tools, sampling devices and containers, monitoring instruments, radios, clipboards, etc.) on plastic drop cloths or in different containers with plastic liners. Each will be contaminated to a different degree. Segregation at the drop reduces the probability of cross-contamination.

Equipment:
- various size containers
- plastic liners
- plastic drop cloths

Station 2: Boot Cover and Glove Wash

Scrub outer boot covers and gloves with decon solution or detergent/ water.

Equipment:
- container (20-30 gallons)
- decon solution or detergent water
- 2-3 long-handle, soft-bristle scrub-brushes

Station 3: Boot Cover and Glove Rinse

Rinse off decon solution from Station 2 using copious amounts of water. Repeat as many times as necessary.

Equipment: - container (30-50 gallons) or high-pressure spray unit water
- 2-3 long-handle, soft-bristle scrub-brushes

Station 4: Tape Removal

Remove tape around boots and gloves and deposit in container with plastic liner.

Equipment: - container (20-30 gallons)
- plastic liners

Station 5: Boot Cover Removal

Remove boot covers and deposit in container with plastic liner.

Equipment: - container (30-50 gallons)
- plastic liners
- bench or stool

Station 6: Outer Glove Removal

Remove outer gloves and deposit in container with plastic liner.

Equipment: - container (20-30 gallons)
- plastic liners

Station 7: Suit/Safety Boot Wash

Thoroughly wash fully encapsulating suit and boots. Scrub suit and boots with long-handle, soft-bristle scrub brush and copious amounts of decon solution or detergent/water. Repeat as many times as necessary.

Equipment: - container (30-50 gallons)
- decon solution or detergent/water
- 2-3 long-handle, soft-bristle scrub-brushes

Station 8: Suit/Safety Boot Rinse

Rinse off decon solution or detergent/water using copious amounts of water. Repeat as many times as necessary.

Equipment: - container (30-50 gallons) or high-pressure spray unit
- water

- 2-3' long handle, soft-bristle scrub brushes

Station 9: Tank Change

If worker leaves Exclusion Zone to change air tank, this is the last step in the decontamination procedure. Worker's air tank is exchanged, new outer gloves and boots covers donned, and joints taped. Worker then returns to duty.

Equipment:
- air tanks
- tape
- boot covers
- gloves

Station 10: Safety Boot Removal

Remove safety boots and deposit in container with plastic liner.

Equipment:
- container (30-50 gallons)
- plastic liners
- bench or stool
- boot jack

Station 11: Fully Encapsulating Suit and Hard Hat Removal

With assistance of helper, remove fully encapsulating suit (and hard hat). Hang suits on rack or lay out on drop cloths.

Equipment:
- rack
- drop cloths
- bench or stool

Station 12: SCBA Backpack Removal

While still wearing facepiece, remove backpack and place on table. Disconnect hose from regulator valve and proceed to next station.

Equipment:
- table

Station 13: Inner Glove Wash

Wash with decon solution or detergent/water that will not harm skin. Repeat as many times as necessary.

Equipment:
- basin or bucket
- decon solution or detergent/water
- small table

Station 14: Inner Glove Rinse

Rinse with water. Repeat as many times as necessary.

Equipment:
- water basin
- basin or bucket
- small table

Station 15: Facepiece Removal

Remove facepiece. Deposit in container with plastic liner. Avoid touching face with fingers.

Equipment:
- container (30-50 gallons)
- plastic liners

Station 16: Inner Glove Removal

Remove inner gloves and deposit in container with plastic liner.

Equipment:
- container (20-30 gallons)
- plastic liners

Station 17: Inner Clothing Removal

Remove clothing soaked with perspiration. Place in container with plastic liner. Inner clothing should be removed as soon as possible since there is a possibility that small amounts of contaminants might have been transferred in removing fully encapsulating suit.

Equipment:
- container (30-50 gallons)
- plastic liners

Station 18: Field Wash

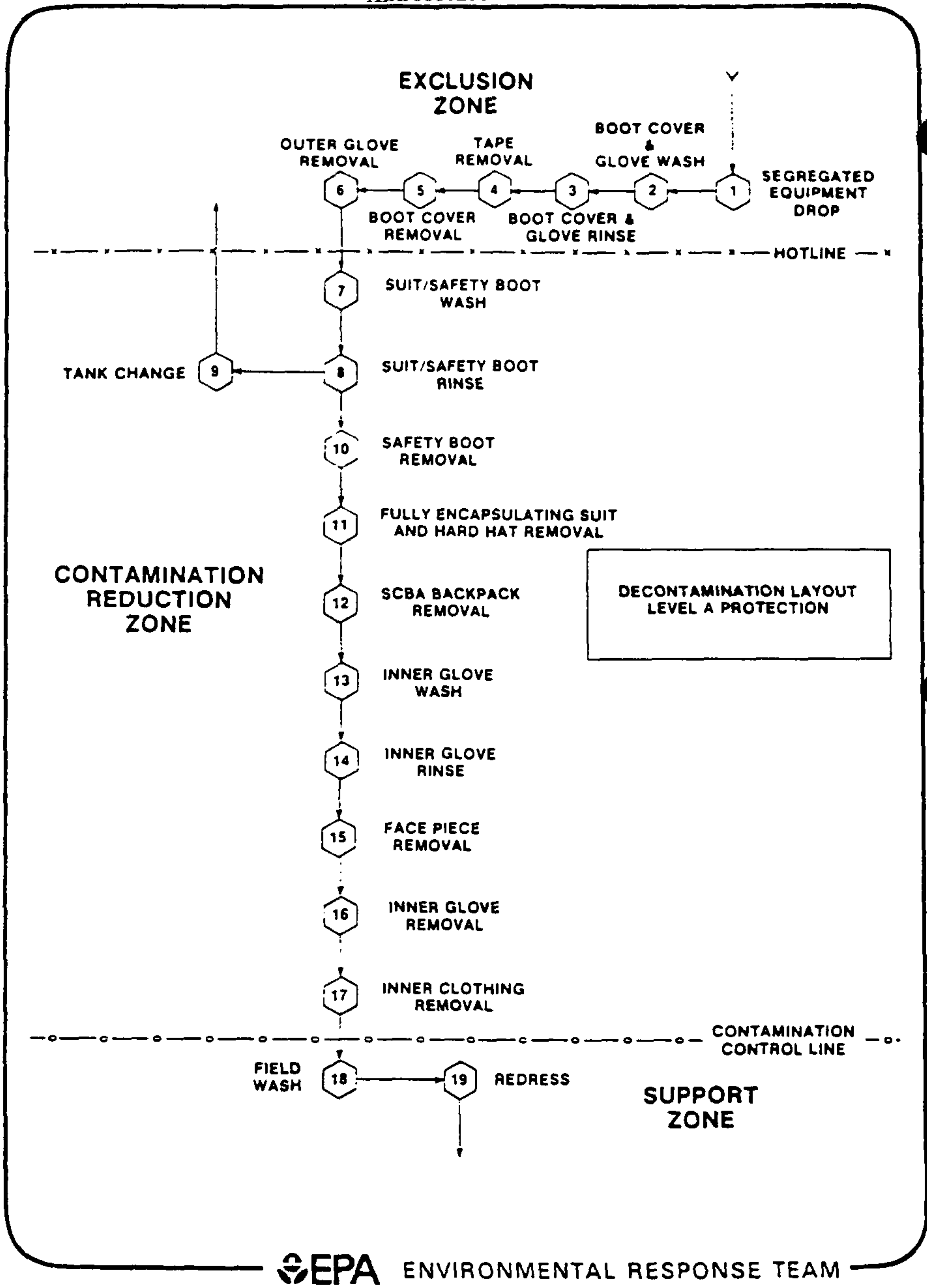
Shower if highly toxic, skin-corrosive or skin-absorbable materials are known or suspected to be present. Wash hands and face if shower is not available.

Equipment:
- water
- soap
- small table
- basin or bucket, or
- field showers
- towels

Station 19: Redress

Put on clean clothes. A dressing trailer is needed in inclement weather.

Equipment:
- tables
- chairs
- lockers
- clothes


EXCLUSION ZONE
SEGREGATED EQUIPMENT DROP
BOOT COVER & GLOVE WASH
BOOT COVER & GLOVE RINSE
TAPE REMOVAL
BOOT COVER REMOVAL
OUTER GLOVE REMOVAL
HOTLINE
SUIT/SAFETY BOOT WASH
SUIT/SAFETY BOOT RINSE
TANK CHANGE
SAFETY BOOT REMOVAL
FULLY ENCAPSULATING SUIT AND HARD HAT REMOVAL
CONTAMINATION REDUCTION ZONE
SCBA BACKPACK REMOVAL
DECONTAMINATION LAYOUT LEVEL A PROTECTION
INNER GLOVE WASH
INNER GLOVE RINSE
FACE PIECE REMOVAL
INNER GLOVE REMOVAL
INNER CLOTHING REMOVAL
CONTAMINATION CONTROL LINE
FIELD WASH
REDRESS
SUPPORT ZONE
EPA ENVIRONMENTAL RESPONSE TEAM

ANNEX 2

LEVEL B DECONTAMINATION

A. EQUIPMENT WORN

The full decontamination procedure outlined is for workers wearing Level B protection (with taped joints between gloves, boot, and suit) consisting of:

- One-piece, hooded, chemical-resistant splash suit
- Self-contained breathing apparatus
- Hard hat
- Chemical-resistant, steel toe and shank boots
- Boot covers
- Inner and outer gloves

B. PROCEDURE FOR FULL DECONTAMINATION

Station 1: Segregated Equipment Drop

Deposit equipment used on-site (tools, sampling devices and containers, monitoring instruments, radios, clipboards, etc.) on plastic drop cloths or in different containers with plastic liners. Each will be contaminated to a different degree. Segregation at the drop reduces the probability of cross-contamination.

Equipment:
- various size containers
- plastic liners
- plastic drop cloths

Station 2: Boot Cover and Glove Wash

Scrub outer boot covers and gloves with decon solution or detergent/water.

Equipment:
- container (20-30 gallons)
- decon solution or
- detergent water
- 2-3 long-handle, soft-bristle scrub-brushes

Station 3: Boot Cover and Glove Rinse

Rinse off decon solution from Station 2 using copious amounts of water. Repeat as many times as necessary.

Equipment:
- container (30-50 gallons) or
- high-pressure spray unit
- water
- 2-3 long-handle, soft-bristle scrub-brushes

Station 4: Tape Removal

Remove tape around boots and gloves and deposit in container with plastic liner.

Equipment:
- container (20-30 gallons)
- plastic liners

Station 5: Boot Cover Removal

Remove boot covers and deposit in container with plastic liner.

Equipment:
- container (30-50 gallons)
- plastic liners
- bench or stool

Station 6: Outer Glove Removal

Remove outer gloves and deposit in container with plastic liner.

Equipment:
- container (20-30 gallons)
- plastic liners

Station 7: Suit/Safety Boot Wash

Thoroughly wash chemical-resistant splash suit, SCBA, gloves, and safety boots. Scrub with long-handle, soft-bristle scrub brush and copious amounts of decon solution or detergent/water. Wrap SCBA regulator (if belt-mounted type) with plastic to keep out water. Wash backpack assembly with sponges or cloths.

Equipment:
- container (30-50 gallons)
- decon solution or
- detergent/water
- 2-3 long-handle, soft-bristle scrub-brushes
- small buckets
- sponges or cloths

Station 8: Suit/SCBA/Boot/Glove Rinse

Rinse off decon solution or detergent/water using copious amounts of water. Repeat as many times as necessary.

Equipment:
- container (30-50 gallons)
- high-pressure spray unit
- water
- small buckets
- 2-3 long-handle, soft-bristle scrub-brushes
- sponges or cloths

Station 9: Tank Change

If worker leaves Exclusion Zone to change air tank, this is the last step in the decontamination procedure. Worker's air tank is exchanged, new outer gloves and boots covers donned, and joints taped. Worker returns to duty.

Equipment:
- air tanks
- tape
- boot covers
- gloves

Station 10: Safety Boot Removal

Remove safety boots and deposit in container with plastic liner.

Equipment:
- container (30-50 gallons)
- plastic liners
- bench or stool
- boot jack

Station 11: SCBA Backpack Removal

While still wearing facepiece, remove backpack and place on table. Disconnect hose from regulator valve and proceed to next station.

Equipment:
- table

Station 12: Splash Suit Removal

With assistance of helper, remove splash suit. Deposit in container with plastic liner.

Equipment:
- container (30-50 gallons)
- plastic liners
- bench or stool

Station 13: Inner Glove Wash

Wash inner gloves with decon solution or detergent/water that will not harm skin. Repeat as many times as necessary.

Equipment:
- decon solution or
- detergent/water
- basin or bucket
- small table

Station 14: Inner Glove Rinse

Rinse inner gloves with water. Repeat as many times as necessary.

Equipment:
- water
- basin or bucket
- small table

Station 15: Facepiece Removal

Remove facepiece. Avoid touching face with gloves. Deposit in container with plastic liner.

Equipment:
- container (30-50 gallons)
- plastic liners

Station 16: Inner Glove Removal

Remove inner gloves and deposit in container with plastic liner.

Equipment:
- container (20-30 gallons)
- plastic liners

Station 17: Inner Clothing Removal

Remove clothing soaked with perspiration. Place in container with plastic liner. Do not wear inner clothing off-site since there is a possibility small amounts of contaminants might have been transferred in removing fully encapsulating suit.

Equipment:
- container (30-50 gallons)
- plastic liners

Station 18: Field Wash

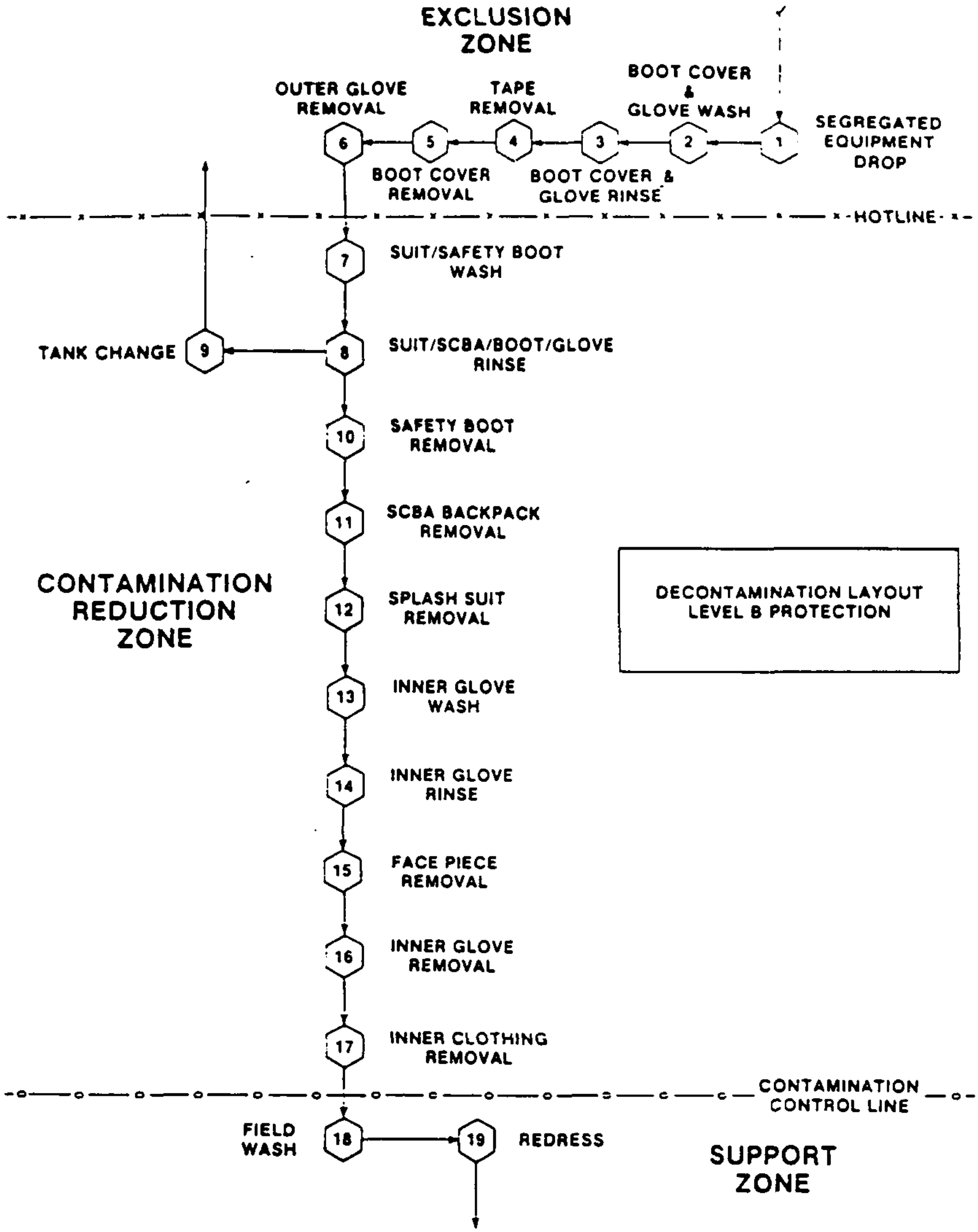
Shower if highly toxic, skin-corrosive, or skin-absorbable materials are known or suspected to be present. Wash hands and face if shower is not available.

Equipment:
- water
- soap
- small tables
- basins or buckets, or
- field showers

Station 19: Redress

Put on clean clothes. A dressing trailer is needed in inclement weather.

Equipment:
- tables
- chairs
- lockers
- clothes



DECONTAMINATION LAYOUT
LEVEL B PROTECTION

ANNEX 3

LEVEL C DECONTAMINATION

A. EQUIPMENT WORN

The full decontamination procedure outlined is for workers wearing Level C protection (with taped joints between gloves, boots, and suit) consisting of:

- One-piece, hooded, chemical-resistant splash suit
- Canister equipped, full-face mask
- Hard hat
- Chemical-resistant, steel toe and shank boots
- Boot covers
- Inner and outer gloves

B. PROCEDURE FOR FULL DECONTAMINATION

Station 1: Segregated Equipment Drop

Deposit equipment used on-site (tools, sampling devices and containers, monitoring instruments, radios, clipboards, etc.) on plastic drop cloths or in different containers with plastic liners. Each will be contaminated to a different degree. Segregation at the drop reduces the probability of cross-contamination.

Equipment:
- various size containers
- plastic liners
- plastic drop cloths

Station 2: Boot Cover and Glove Wash

Scrub outer boot covers and gloves with decon solution or detergent/water.

Equipment:
- container (20-30 gallons)
- decon solution or
- detergent water
- 2-3 long-handle, soft-bristle scrub-brushes

Station 3: Boot Cover and Glove Rinse

Rinse off decon solution from Station 2 using copious amounts of water. Repeat as many times as necessary.

Equipment: - container (30-50 gallons) or
- high-pressure spray unit
- water
- 2-3 long-handle, soft bristle scrub-brushes

Station 4: Ta[e Removal

Remove tape around boots and gloves and deposit in container with plastic liner.

Equipment: - container (20-30 gallons)
- plastic liners

Station 5: Boot Cover Removal;

Remove boot covers and deposit in container with plastic liner.

Equipment: - container (30-50 gallons)
- plastic liners
- bench or stool

Station 6: Outer Glove Removal

Remove outer gloves and deposit in container with plastic liner.

Equipment: - container (20-30 gallons)
- plastic liners

Station 7: Suit/Safety Boot Wash

Thoroughly wash splash suit and safety boots. Scrub with long handle, soft-bristle scrub brush and copious amounts of decon solution or detergent/water. Repeat as many times as necessary.

Equipment: - container (30-50 gallons)
- decon solution or
- detergent/water
- 2-3 long-handle, soft-bristle scrub-brushes

Station 8: Suit/Safety Boot Rinse

Rinse off decon solution or detergent/water using copious amounts of water. Repeat as many times as necessary.

Equipment: - container (30-50 gallons) or
- high-pressure spray unit
- water

- 2-3 long-handle, soft-bristle scrub-brushes

Station 9: Canister or Mask Change

If worker leaves Exclusion Zone to change canister (or mask), this is the last step in the decontamination procedure. Worker's canister is exchanged, new outer gloves and boots covers donned, and joints taped. Worker returns to duty.

Equipment:
- canister (or mask)
- tape
- boot covers
- gloves

Station 10: Safety Boot Removal

Remove safety boots and deposit in container with plastic liner.

Equipment:
- container (30-50 gallons)
- plastic liners
- bench or stool
- boot jack

Station 11: Splash Suit Removal

With assistance of helper, remove splash suit. Deposit in container with plastic liner.

Equipment:
- container (30-50 gallons)
- bench or stool
- liner

Station 12: Inner Glove Wash

Wash inner gloves with decon solution or detergent/water that will not harm skin. Repeat as many times as necessary.

Equipment:
- decon solution or
- detergent/water
- basin or bucket

Station 13: Inner Glove Rinse

Rinse inner gloves with water. Repeat as many times as necessary.

Equipment:
- water
- basin or bucket
- small table

Station 14: Facepiece Removal

Remove facepiece. Avoid touching face with gloves. Deposit facepiece in container with plastic liner.

Equipment:
- container (30-50 gallons)
- plastic liners

Station 15: Inner Glove Removal

Remove inner gloves and deposit in container with plastic liner.

Equipment:
- container (20-30 gallons)
- plastic liners

Station 16: Inner Clothing Removal

Remove clothing soaked with perspiration. Place in container with plastic liner. Do not wear inner clothing off-site since there is a possibility small amounts of contaminants might have been transferred in removing splash suit.

Equipment:
- container (30-50 gallons)
- plastic liners

Station 17: Field Wash

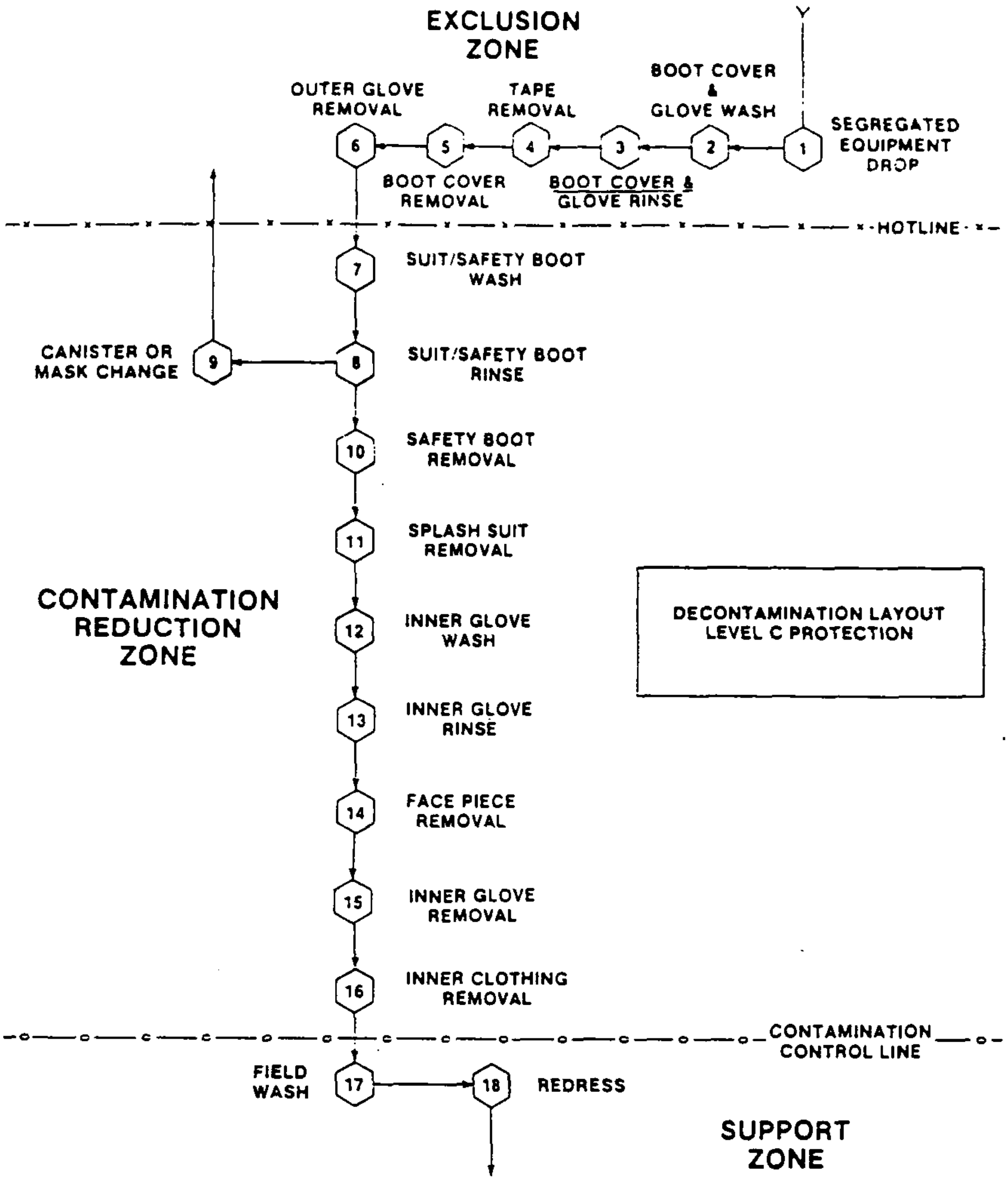
Shower if highly toxic, skin-corrosive or skin-absorbable materials are known or suspected to be present. Wash hands and face if shower is not available.

Equipment:
- water
- soap
- tables
- wash basins/buckets, or
- field showers

Station 18: Redress

Put on clean clothes. A dressing trailer is needed in inclement weather.

Equipment:
- tables
- chairs
- lockers
- clothes



EPA ENVIRONMENTAL RESPONSE TEAM

ANNEX 4

LEVEL A DECONTAMINATION, MINIMUM LAYOUT

A. EQUIPMENT WORN

The decontamination procedure outlined is for workers wearing Level A protection (with taped joints between gloves, boots, and suit) consisting of:

- Fully encapsulating suit with integral boots and gloves
- Self-contained breathing apparatus
- Hard hat (optional)
- Chemical-resistant, steel toe and shank boots
- Boot covers
- Inner and outer gloves

B. PROCEDURE FOR FULL DECONTAMINATION

Station 1: Segregated Equipment Drop

Deposit equipment used on-site (tools, sampling devices and containers, monitoring instruments, radios, clipboards, etc.) on plastic drop cloths or in different containers with plastic liners. Each will be contaminated to a different degree. Segregation at the drop reduces the probability of cross-contamination.

Equipment:
- various size containers
- plastic liners
- plastic drop cloths

Station 2: Outer Garment, Boots, and Gloves Wash and Rinse

Scrub outer boots, outer gloves, and fully-encapsulating suit with decon solution or detergent water. Rinse off using copious amounts of water.

Equipment:
- containers (30-50 gallons)
- decon solution or
- detergent water
- rinse water
- 2-3 long-handle, soft-bristle scrub-brushes

Station 3: Outer Boot and Glove Removal

Remove outer boots and gloves. Deposit in container with plastic liner.

Equipment:
- container (30-50 gallons)
- plastic liners
- bench or stool

Station 4: Tank Change

If worker leaves Exclusion Zone to change air tank, this is the last step in the decontamination procedure. Worker's air tank is exchanged, new outer gloves and boot covers donned, joints taped, and worker returns to duty.

Equipment:
- air tanks
- tape
- boot covers
- gloves

Station 5: Boot, Gloves, and Outer Garment Removal

Boots, fully-encapsulating suit, and inner gloves removed and deposited in separate containers lined with plastic.

Equipment:
- containers (30-50 gallons)
- plastic liners
- bench or stool

Station 6: SCBA Removal

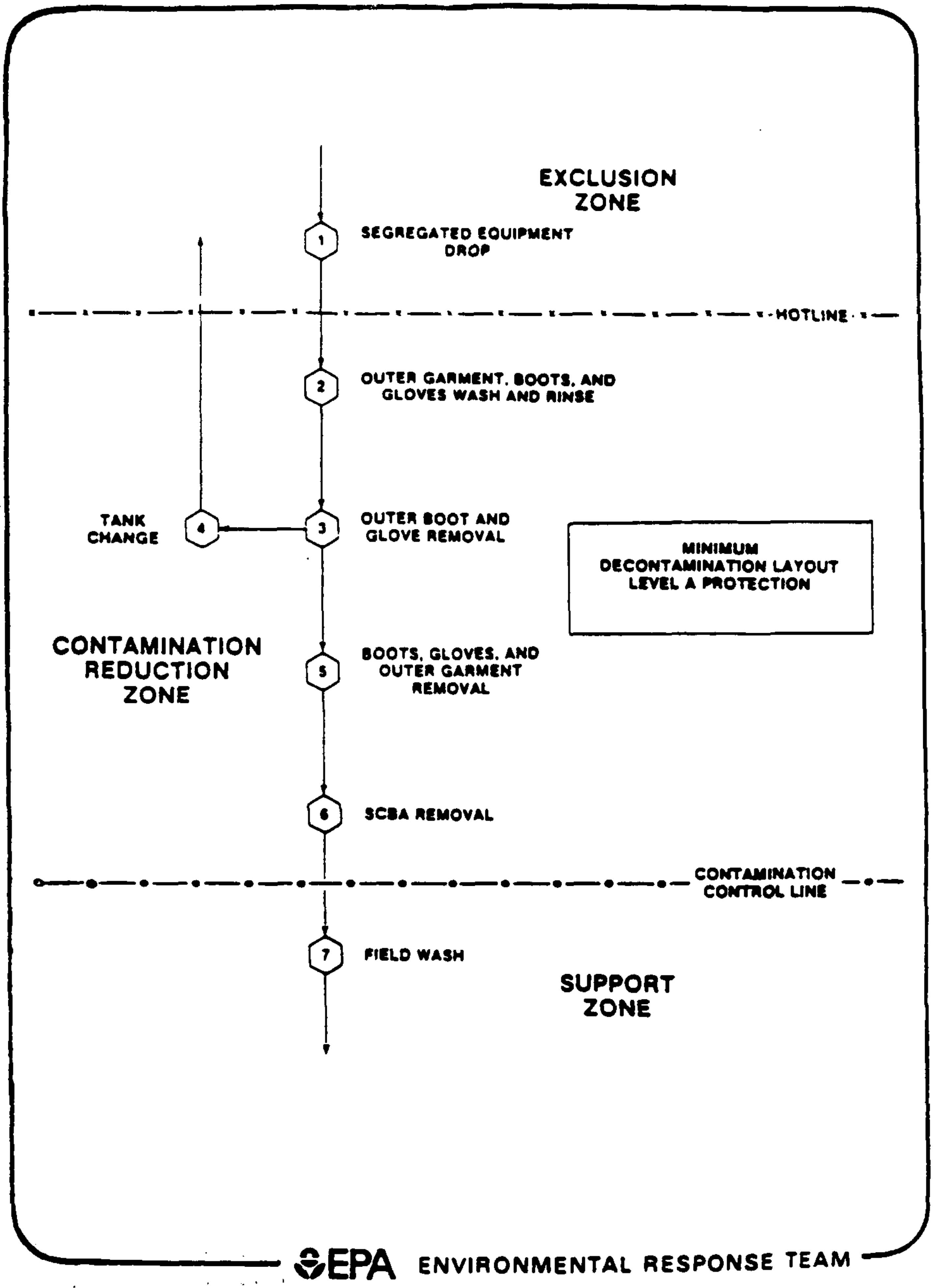
SCBA backpack and facepiece is removed. Hands and face are thoroughly washed. SCBA deposited on plastic sheets.

Equipment:
- plastic sheets
- basin or bucket
- soap and towels
- bench

Station 7: Field Wash

Thoroughly wash hands and face. Shower as soon as possible.

Equipment:
- water
- soap
- tables
- wash basin/bucket1


EXCLUSION ZONE
1 SEGREGATED EQUIPMENT DROP
HOTLINE
2 OUTER GARMENT, BOOTS, AND GLOVES WASH AND RINSE
TANK CHANGE 4
3 OUTER BOOT AND GLOVE REMOVAL
MINIMUM DECONTAMINATION LAYOUT LEVEL A PROTECTION
CONTAMINATION REDUCTION ZONE
5 BOOTS, GLOVES, AND OUTER GARMENT REMOVAL
6 SCBA REMOVAL
CONTAMINATION CONTROL LINE
7 FIELD WASH
SUPPORT ZONE
EPA ENVIRONMENTAL RESPONSE TEAM