Section II. Emergency Medical Services Response to Hazardous Materials Incidents

Hazard Recognition

When dispatched to the scene of an incident, emergency response personnel may not be aware that the situation involves hazardous materials. As a result, emergency medical services personnel should always be alert to the possibility that they may be dealing with a chemically contaminated individual, and should ask the dispatch personnel and victims about the nature of the event. An injury at a hazardous materials incident need not invariably involve chemical exposure: it could have resulted from a physical accident, such as slipping off a ladder. But as a routine precaution, the involvement of hazardous materials should be considered a possibility on every call. The manual *Recognizing and Identifying Hazardous Materials* (produced by the National Fire Academy and the National Emergency Training Center) states that there are six primary clues that may signify the presence of hazardous materials. These clues are included below to facilitate and expedite the prompt and correct identification of any hazardous materials at the scene of an incident. Dispatch protocols should seek to obtain information about these clues and relay the information to field personnel as soon as possible. Certain combinations of patient symptoms such as nausea, dizziness, burning eyes or skin, or cyanosis should also suggest to the dispatch staff the presence of hazardous materials.

The six principle clues to hazardous materials incidents are:

- **Occupancy and Location.** Community preplanning should identify the specific sites that contain hazardous materials. In addition, emergency personnel should be alert to the obvious locations in their communities that use and/or store hazardous materials (e.g., laboratories, factories, farm and paint supply outlets, construction sites). The Department of Labor s Material Safety Data Sheets (MSDSs) should also be available, especially for any particularly dangerous chemicals kept on site. It should be kept in mind, however, that these data sheets may have incomplete information and that the medical information provided is generally at a basic first aid level.

- **Container Shape.** Department of Transportation (DOT) regulations delineate container specifications for the transport of hazardous materials. There are three categories of packaging: stationary bulk storage containers at fixed facilities that come in a variety of sizes and shapes; bulk transport vehicles, such as rail and truck tank cars, that vary in shape depending upon the cargo; and labeled fiberboard boxes, drums, or cylinders for smaller quantities of hazardous materials. The shape and configuration of the container can often be a useful clue to the presence of hazardous materials.

- **Markings/Colors.** Certain transportation vehicles must use DOT markings, including identification (ID) numbers. Identification numbers, located on both ends and both sides, are required on all cargo tanks, portable tanks, rail tank cars, and other packages that carry hazardous materials. Railcars may have the names of certain substances stenciled on the side of the car. A marking scheme designed by the National Fire Protection Association (NFPA 704M System) identifies hazard characteristics of materials at terminals and industrial sites, but does not provide product-specific information. This system uses a diamond divided into four quadrants. Each quadrant represents a different characteristic: the left, blue section refers to health; the top, red quarter pertains to flammability; the right, yellow area is for reactivity; and the bottom, white quadrant highlights special information (e.g., ~~W~~ indicates dangerous when wet, Oxy stands for oxidizer).

A number from zero through four in each quadrant indicates the relative risk of the hazard, with zero representing the minimum risk. This system does not indicate what the product is, the quantity, or its exact location. In addition, it does not reveal the compound s reactivity with other chemicals. The military also uses distinctly shaped markings and signs to designate certain hazards. These markings may be found on vehicles, on the products themselves, or on shipping papers.

- **Placards/Labels.** These convey information through use of colors, symbols, Hazard Communication Standards, American National Standard Institute (ANSI) Standards for Precautionary Labeling of Hazardous Industrial Chemicals, United Nations Hazard Class Numbers, and either hazard class wording or four-digit identification numbers. Placards are used when hazardous materials are being stored in bulk (usually over 1,001 lb), such as in cargo tanks. Labels designate hazardous materials kept in smaller packages. Caution must be exercised, however, because the container or vehicle holding a hazardous material may be improperly labeled or recorded, or it may not have any exterior warning.

- **Shipping Papers.** Shipping papers can clarify what is labeled as dangerous on placards. They should provide the shipping name, hazard class, ID number, and quantity, and may indicate whether the material is waste or poison. Shipping papers, which must accompany all hazardous material shipments, are now required to list a 24-hour emergency information telephone number. The location where the shipping papers are stored can be problematical; often they are found in close proximity to the hazardous material(s) or in other locations not easily accessible during an emergency. Shipping papers should remain at the incident scene for use by all response personnel.

- **Senses.** Odor, vapor clouds, dead animals or fish, fire, and skin or eye irritation can signal the presence of hazardous materials. Generally, if one detects an odor of hazardous materials, it should be assumed that exposure has occurred and the individual is still in the danger area, although some chemicals have a detectable odor at levels below their toxic concentrations. Some chemicals, however, can impair an individual s sense of smell (e.g., hydrogen sulfide), and others have no odor, color, or taste at all (e.g., carbon monoxide). Binoculars are helpful to ascertain visible information from a safe distance.

Appendix A provides greater detail on NFPA s 704M system; the DOT s hazardous materials marking, labeling, and placarding guide; and the Department of Labor s MSDS. It is important that any and all available clues are used in substance identification, especially obvious sources such as the information provided on a label or in shipping papers.

The aim of emergency personnel should be to make a chemical-specific identification while exercising caution to prevent exposure to any chemicals. Identifying the hazardous material and obtaining information on its physical characteristics and toxicity are vital steps to the responder s safety and effective management of the hazardous materials incident. Since each compound has its own unique set of physical and toxicological properties, early and accurate identification of the hazardous material(s) involved allows emergency personnel to initiate appropriate management steps at the scene.

Many resources are available to provide information concerning response to and planning for hazardous materials incidents. A selected bibliography of written material is included at the end of each section of this guidebook; it is not, however, a complete list of the materials available. Printed reference materials provide several advantages: they are readily available, they can be kept in the response vehicle, they are not dependent on a power source or subject to malfunction, and they are relatively inexpensive. Disadvantages include the difficulty of determining the correct identity for an unknown chemical through descriptive text, the logistics of keeping the materials current, the increased risk of the documents being lost or damaged because of their small size and soft cover bindings, and the problem that no single volume is capable of providing all the information that may be needed. EMS personnel should have immediate access to and be proficient at using the DOT s *North American Emergency Response Guidebook* and other medically-oriented response documentation.

There is also a vast array of telephone and computer-based information sources concerning hazardous materials. They can help by describing the toxic effects of a chemical, its relative potency, and the potential for secondary contamination. They may also recommend decontamination procedures, clinical management strategies, and advice on the adequacy of specific types of protective gear. Exhibit II-lA is a partial listing of the many information resources available by telephone. Exhibit II-1B is a list of suggested telephone numbers that should be filled in for your community. The regional Poison Control Center, the Soldier and Biological Chemical Command (SBCCOM), and the Centers for Disease Control (CDC) can be contacted 24 hours a day to provide vital information on the medical management of hazardous materials exposure. Exhibit II-2 provides a partial listing of the available computerized and online information sources. Note, however, that not all online databases are peer reviewed; some medical management information may be based only on DOT or MSDS data. Care should be exercised when selecting information sources. Planning is an essential part of every response, and many of these resources can provide guidance in the formation of an effective response plan.

Exhibit II-1A
Telephone Information and Technical Support References

Resource	Contact	Services Provided
Chemical Transportation Emergency Center (CHEMTREC)	1-800-424-9300	24-hour emergency number connecting with manufacturers and/or shippers. Advice provided on handling, rescue gear, decontamination considerations, etc. Also provides access to the Chlorine Emergency Response Plan (CHLOREP).
Agency for Toxic Substances and Disease Registry (ATSDR)	1-404-639-6360	24-hour emergency number for health-related support in hazardous materials emergencies, including onsite assistance.
Bureau of Explosives	1-719-585-1881	Contact number for technical questions about railway transport of hazardous materials. For emergencies, call CHEMTREC (1-800-424-9300).
Emergency Planning and Community Right-to-Know Act (EPCRA) and Resource Conservation and Recovery Act (RCRA) Information Hotline	1-800-424-9346	Available 9:00 a.m. to 6:00 p.m. (EST). Provides information on SARA Title III, list of extremely hazardous substances, and planning guidelines.
Environmental Protection Agency (EPA) Regional Offices	website: www.epa.gov/regional	Environmental response teams available for technical assistance.
Region I (CT, ME, MA, NH, RI, VT)	1-617-918-1111	
Region II (NJ, NY, PR, VI)	1-212-637-3000	
Region III (DE, DC, MD, PA, VA, WV)	1-215-814-2900; intra-regional only: 1-800-438-2474	
Region IV (AL, FL, GA, KY, MS, NC, SC, TN)	1-404-562-9900; Emergency Response & Removal Branch: 1-800-564-7577	
Region V (IL, IN, MI, MN, OH, WI)	1-312-353-2000	
Region VI (AR, LA, NM, OK, TX)	1-214-665-2200	
Region VII (IA, KS, MO, NE)	1-913-551-7003	
Region VIII (CO, MT, ND, SD, UT, WY)	1-303-312-6312	
Region IX (AZ, CA, HI, NV; Pacific Islands AS, FM, GU, MH, MP, PW)	1-415-744-1500; emergencies: 1-415-744-2000	
Region X (AK, ID, OR, WA)	1-206-553-1200	

Exhibit II-1A (continued)

Resource	Contact	Services Provided
National Animal Poison Control Center	1-800-548-2423 1-888-426-4435	24-hour consultation services concerning animal poisonings or chemical contamination. Provides an emergency response team to investigate incidents and to perform laboratory analysis.
National Pesticides Information Retrieval System (NPIRS)	1-765-494-6616 website: ceris.purdue.edu/npirs	Contact information for help in searching NPIRS database to get fact sheets on pesticides, insecticides, fungicides, and state and federally registered chemicals.
National Pesticide Telecommunications Network (NPTN) (Oregon State University)	1-800-858-7378 website: ace.orst.edu/info/nptn	Provides information about pesticide-related topics, including pesticide products, recognition and management of pesticide poisoning, toxicology, environmental chemistry, referrals for laboratory analyses, investigation of pesticide incidents, emergency treatment, safety, health and environmental effects, cleanup, and disposal procedures.
National Response Center	1-800-424-8802	A federal hotline for reporting oil and chemical spills where hazardous materials are responsible for death, serious injury, property damage in excess of $50,000, or continuing danger to life and property.
U.S. Army Soldier and Biological Chemical Command (SBCCOM)	1-800-368-6498	24-hour consultation service for threats and releases pertaining to chemical and biological agents.

Exhibit II-1B
Local Telephone Information and Technical Support Resource Worksheet

Resource	Contact (fill in for future reference)	Services Provided (fill in for future reference)
EPA Regional or State Office		
Regional Poison Control Center		
State Emergency Response Commission		
State Health Department		
State Emergency Management Office		
Local Fire Department		
Local Hazardous Materials		
Response Team		
Community Police Department		
Local Emergency Planning Committee		
Local Health Department		
State Department of Natural Resources		
FEMA Regional Office		
State Agriculture Office		
State Lab Office		
State EMS Office		
Hyperbaric Medicine Chamber		
Burn Center		
CDC		
U.S. Army Soldier and Biological Chemical Command		

Exhibit II-2
Computerized Data Sources for Information and Technical Support

Data System	Contact	Description
CAMEO	CAMEO Database Manager National Oceanic and Atmospheric Administration (NOAA) Hazardous Materials Response Division 7600 Sand Point Way, N.E. Seattle, Washington 98115 (206) 526-6317 website: www.epa.gov/ceppo/cameo	Computer-aided management of emergency operations available to on-scene responder(s). Chemical identification database assists in determining substance(s) involved, predicting downwind concentrations, providing response recommendations, and identifying potential hazards.
CHRIS	CIS, Inc. c/o Oxford Molecular Group 11350 McCormick Road Executive Plaza, Suite 1100 Hunt Valley, Maryland 21031 (800) 247-8737 website: www.oxmol.com/software/cis/details/CHRIS.shtml	Chemical Hazard Response Information System, developed by the Coast Guard and comprised of reviews on fire hazards, fire-fighting recommendations, reactivities, physicochemical properties, health hazards, use of protective clothing, and shipping information for over 1,000 chemicals.
HAZARDTEXT	Micromedex, Inc. Suite 300 6200 S. Syracuse Way Englewood, Colorado 80111-4740 (800) 525-9083 website: www.micromedex.com/products/pd-main.htm	Assists responders dealing with incidents involving hazardous materials, such as spills, leaks, and fires. Provides information on emergency medical treatment and recommendations for initial hazardous response.
HMIS	Kevin Coburn Information Systems Manager U.S. Department of Transportation D.H.M. 63 - Room 8104 400 7th Street SW Washington, D.C. 20590-0001 website: www.dlis.dla.mil/hmis.htm	Hazardous Material Information Systems contains information on hazardous materials. Transportation-related incidents may be reported on DOT form 5800.1 (Hazardous Materials Incident Report Form).
HSDB	HSDB Representative National Library of Medicine Specialized Information Systems 8600 Rockville Pike Bethesda, Maryland 20894 (301) 496-6531 website: sis.nlm.nih.gov/sis1	Hazardous Substances Data Bank, compiled by the National Library of Medicine, provides reviews on the toxicity, hazards, and regulatory status of over 4,000 frequently used chemicals.

Exhibit II-2 (continued)

Data System	Contact	Description
1st MEDICAL RESPONSE PROTOCOLS	Micromedex, Inc. Suite 300 6200 S. Syracuse Way Englewood, Colorado 80111 (800) 525-9083 website: www.micromedex.com/products/pd-main.htm	Helps develop training programs and establish protocols for first aid or initial workplace response to a medical emergency.
MEDITEXT	Micromedex, Inc. Suite 300 6200 S. Syracuse Way Englewood, Colorado 80111 (800) 525-9083 website: www.micromedex.com/products/pd-main.htm	Provides recommendations regarding the evaluation and treatment of exposure to industrial chemicals.
OHMTADS	Oxford Molecular Group, Inc. 11350 McCormick Rd. Executive Plaza 3, Suite 1100 Hunt Valley, Maryland 21031 (800) 247-8737 website: www.oxmol.com/software/cis/details/OHMTADS.shtml	Oil and Hazardous Materials/Technical Assistance Data Systems provides information on the effects of spilled chemical compounds and their hazardous characteristics and properties, assists in identifying unknown substances, and recommends procedures for handling cleanups.
TOMES	Micromedex, Inc. Suite 300 6200 S. Syracuse Way Englewood, Colorado 80111 (800) 525-9083 website: www.micromedex.com/products/pd-main.htm	The Tomes Plus Information Systems is a series of comprehensive databases on a single CD-ROM disc. It provides information regarding hazardous properties of chemicals and medical effects from exposure. The Tomes Plus database contains Meditext, Hazardtext, HSBD, CHRIS, OHMTADS, and 1st Medical Response Protocols.
TOXNET	Toxicology Data Network (TOXNET) National Library of Medicine Specialized Information Services 8600 Rockville Pike Bethesda, Maryland 20894 (301) 496-6531 website: sis.nlm.nih.gov/sis1	A computerized system of three toxicologically oriented data banks operated by the National Library of Medicine the Hazardous Substances Data Bank, the Registry of Toxic Effects of Chemical Substances, and the Chemical Carcinogenesis Research Information System. TOXNET provides information on the health effects of exposure to industrial and environmental substances.

Principles of Toxicology for Emergency Medical Service Personnel

Exposure to hazardous chemicals may produce a wide range of adverse health effects. The likelihood of an adverse health effect occurring, and the severity of the effect, are dependent on: (1) the toxicity of the chemical; (2) the route of exposure; (3) the nature and extent of exposure; and (4) factors that affect the susceptibility of the exposed person, such as age and the presence of chronic disease. To better understand potential health effects, emergency medical personnel should understand the basic principles and terminology of toxicology.

Toxicology is the science that deals with poisons and their effect on living organisms. Examples of these adverse effects, sometimes called toxic end points, include carcinogenicity (development of cancer), hepatotoxicity (liver damage), neurotoxicity (nervous system damage), and nephrotoxicity (kidney damage). This is merely a sample list of toxic end points that might be encountered (Exhibit II-3).

Toxic chemicals often produce injuries at the site which they come into contact with the body. A chemical injury at the site of contact, typically the skin and the mucous membranes of the eyes, nose, mouth, or respiratory tract, is termed a *local toxic effect.* Irritant gases such as chlorine and ammonia can, for example, produce a localized toxic effect in the respiratory tract, while corrosive acids and bases can result in local damage to the skin. In addition, a toxic chemical may be absorbed into the bloodstream and distributed to other parts of the body, producing *systemic effects*. Many pesticides, for example, are absorbed through the skin, distributed to other parts of the body, and produce adverse effects such as neurological, cardiac, respiratory, or other problems. It is important for medical providers to recognize that exposure to chemical compounds can result not only in the development of a single systemic effect but also in the development of multiple systemic effects or a combination of systemic and local effects. Some of these effects may be delayed, sometimes for as long as 48 hours or more. Health effects can also be acute or chronic. Acute health effects are short-term effects that manifest within hours or days, such as vomiting or diarrhea. Chronic health effects are long-term effects that may take years to manifest, such as cancer.

Routes and Extent of Exposure

There are three main routes of chemical exposure: inhalation, dermal contact (with skin or mucous membranes), and ingestion. *Inhalation* results in the rapid introduction of toxic compounds into the respiratory system. Most of the compounds that are commonly inhaled are gases or vapors of volatile liquids. However, solids and liquids can be inhaled as dusts or aerosols. Inhalation of toxic agents generally results in a rapid and effective absorption of the compound into the bloodstream because of the large surface area of the lung tissue and number of blood vessels in the lungs. Knowing a chemical s vapor pressure (VP) can be useful in determining the inhalation risk for a particular exposure. The lower the VP, the less likely the chemical will produce an inhalable gas and vice versa. Water solubility is also an important contributor for symptom development. Irritant agents that are water soluble usually cause early upper respiratory tract irritation, resulting in coughing and throat irritation. Partially water-soluble chemicals penetrate into the lower respiratory system, causing delayed symptoms (12 to 24 hours) which include trouble breathing, pulmonary edema, and coughing up blood. Asphyxiants are chemicals that impede the body s ability to obtain or utilize oxygen. Simple asphyxiants are inert gases (e.g., argon, propane, nitrogen) that displace oxygen in inspired air. Chemical asphyxiants produce harm by preventing oxygen delivery or utilization for energy production by the body s cells. Carbon monoxide and cyanide are examples of asphyxiants.

Exhibit II-3
Examples of Adverse Health Effects from Exposure to Toxic Chemicals

Toxic End Point	Target Organ Systems	Example of Causative Agent	Health Effect Acute	Health Effect Chronic
Carcinogenicity	All	Benzene	Dermatitis Headache Dizziness Sleepiness	Acute myelogenous leukemia
Hepatotoxicity	Liver	1, 1, 1-1 trichloroethane	Vomiting Abdominal pain Dizziness	Liver necrosis Fatty liver
Neurotoxicity	Nervous system	Lead	Nausea Vomiting Abdominal pain	Wrist drop IQ deficits Encephalopathy
Nephrotoxicity	Kidney	Cadmium	Vomiting Diarrhea Chest pain	Kidney damage Anemia

Dermal contact does not typically result in as rapid absorption as inhalation, although some chemicals are readily taken in through the skin. Many organic compounds are lipid (fat) soluble and can therefore be rapidly absorbed through the skin and mucus membranes. Absorption is increased by damage to the skin and by warm weather, and some areas of the body (e.g., the groin) absorb chemicals faster than others (e.g., the hands).

Ingestion is a less common route of exposure for emergency response personnel at hazardous materials incidents. However, incidental hand-to-mouth contact, smoking, and swallowing of saliva and mucus that contains contaminants may also result in exposure by this route. In addition, emergency medical personnel in both hospital and prehospital settings treat chemical exposures in patients who have ingested toxic substances as a result of accidental poisonings or suicide attempts.

Compounds may also be introduced into the body through *injection*, although this is a relatively uncommon scenario in spills or discharges of hazardous materials. Explosions may result in injection injuries and lead to imbedded foreign bodies, which may themselves be chemically contaminated.

The route by which personnel are exposed to a compound plays a role in determining the total amount of the compound taken up by the body because a compound may be absorbed by one route more readily than by another. In addition, the route of exposure may affect the nature of the symptoms that develop. The amount of the compound absorbed by the body also depends on the duration of exposure and the concentration of the compound to which one is exposed.

It is important to recognize that children may be more susceptible to many toxic exposures. A child s immature central nervous system, liver, and renal system increases his or her susceptibility to injury as a result of exposure to chemicals. Children are also likely to receive a higher dose relative to body weight than an adult. This occurs for a number of reasons. First, children are shorter than adults and since most toxic gases are heavier than air, the concentrations increase as you get closer to the ground. Second, children have a larger lung surface area relative to their weight than adults, as well as a greater respiratory volume (liters/min/kg of body weight). It is also probable that the child s lung is a more effective absorbent surface than that of the adult. Third, children have a larger skin area relative to their weight than do adults, allowing more effective surface area for absorption in dermal exposures. A child s skin is more easily penetrated by chemicals, allowing for a more rapid and effective dermal absorption. Finally, children are more likely to ingest toxic chemicals because of increased hand-to-mouth behavior, including pica. All of these factors may lead to an increased dose relative to size in children as compared to adults, even when they all are exposed to the same scenario.

A complex relationship exists between the total amount of the compound absorbed by the body (dose) and the concentration of that compound in the environment. This relationship is important for emergency response personnel to understand because the adverse effects produced by a toxic compound are often related to the dose of that compound received by a patient. However, because we usually only monitor the concentration of the toxic substance in the environment (e.g., parts per million (ppm) of a compound in air), the actual dose of the compound received by the patient is seldom known. Factors specific to the exposed individual, such as area of skin surface exposed, presence of open wounds or breaks in the skin, and the rate and depth of respirations, are important in estimating the dose of the compound received by the patient. Injuries that disrupt the skin may lead to absorption of chemicals that would not normally penetrate the skin.

Dose-Response Relationship

The effect produced by a toxic compound is primarily a function of the dose. This principle, termed the dose-response relationship, is a key concept in toxicology. Many factors affect the normal dose-response relationship and they should be considered when attempting to extrapolate toxicity data to a specific situation (Exhibit II-4).

Exhibit II-4
Classification of Factors Influencing Toxicity

Type	Examples
Factors related to the chemical	Composition (salt, freebase, etc.); physical characteristics (size, liquid, solid, etc.); physical properties (volatility, solubility, etc.); presence of impurities; breakdown products; carriers
Factors related to exposure	Dose; concentration; route of exposure (inhalation, ingestion, dermal); duration
Factors related to the exposed person	Heredity; immunology; nutrition; hormones; age; sex; health status; preexisting diseases; pregnancy
Factors related to environment	Media (air, water, soil, etc.); additional chemicals present; temperature; humidity; air pressure; and fire

Typically, as the dose increases, the severity of the toxic response increases. Humans exposed to 100 ppm of tetrachloroethylene, a solvent that is commonly used for dry-cleaning fabrics, may experience relatively mild symptoms, such as headache and drowsiness. However, exposure to 200 ppm tetrachloroethylene can result in a loss of motor coordination in some individuals, and exposure to 1,500 ppm tetrachloroethylene for 30 minutes may result in loss of consciousness (Exhibit II-5). As shown in Exhibit II-5, the severity of the toxic effect also depends on the duration of exposure, a factor that influences the dose of the compound in the body.

Toxicity information is often expressed as the dose of a compound that causes an effect in a percentage of the exposed subjects, which are usually experimental animals. These dose-response terms are often found in the Material Safety Data Sheets (MSDSs) and other sources of health information. One dose-response term that is commonly used is the lethal dose 50 (LD_{50}). This is the dose that is lethal to 50 percent of an animal population from exposure by a specific route (except inhalation) when given all in one dose. A similar term is the lethal concentration 50 (LC_{50}), which is the concentration of a material in air that on the basis of respiratory exposure in laboratory tests is expected to kill 50 percent of a group of test animals when administered as a single exposure (usually 1 hour). Exhibit II-6 lists a number of chemicals that may be encountered in dealing with hazardous materials incidents, and the reported acute LD_{50} values of these compounds when they are administered by ingestion to rats.

Exhibit II-5
Dose-Response Relationship for Humans Inhaling Tetrachloroethylene Vapors

Levels in Air	Duration of Exposure	Effects on Nervous System
50 ppm		Odor threshold
100 ppm	7 hours	Headache, drowsiness
200 ppm	2 hours	Dizziness, uncoordination
600 ppm	10 minutes	Dizziness, loss of inhibitions
1,000 ppm	1-2 minutes	Marked dizziness, intolerable eye and respiratory tract irritation
1,500 ppm	30 minutes	Coma

From Exhibit II-6 it can be seen that a dose of 3,000 to 3,800 mg/kg tetrachloroethylene is lethal to 50 percent of rats that received the compound orally; however, only 6.4 to 10 mg/kg of sodium cyanide is required to produce the same effect. Therefore, compounds with low LD_{50} values are more acutely toxic than substances with higher LD_{50} values.

The LD_{50} values that appear on an MSDS or in the literature must be used with caution by emergency medical personnel. These values are an index of only one type of response and give no indication of the ability of the compound to cause nonlethal, adverse or chronic effects. They also do not reflect possible additive effects from the mixture of chemicals sometimes found with exposure to hazardous materials. Furthermore, LD_{50} values typically come from experimental animal studies. Because of the anatomical and physiological differences between animals and humans, it is difficult to compare the effects seen in experimental animal studies to the effects expected in humans exposed to hazardous materials in the field. LC_{50} and LD_{50} values are also usually determined in healthy adult animals. Values determined in young animals may be quite different, as may values determined in animals with an underlying disease. It is known that many chemicals are more toxic (lower LD_{50} or LC_{50} values) in young or newborn animals than in adults. This same age dependence may exist in humans. Because several organs, particularly the brain, are still developing in young children, damage to these organs may be more extensive and can be permanent. Also, infants may not be able to excrete chemicals from the body as efficiently as adults because their kidneys and liver are not fully developed. This may lead to longer and greater exposure to the chemical than would occur in an adult with the same relative exposure. The immaturity of metabolizing enzymes in the liver may lead to either increased or decreased toxicity in infants relative to adults. Which may occur is difficult to predict for many chemicals. Therefore, emergency medical personnel should remember that the LD_{50} and LC_{50} values are only useful for comparing the relative toxicity of compounds.

Exhibit II-6
Acute LD_{50} Values for Representative Chemicals When Administered Orally to Rats

Chemical	Acute Oral LD_{50} (mg/kg)[1]
Sodium cyanide	6.4-10
Pentachlorophenol	50-230
Chlordane	83-560
Lindane	88-91
Toluene	2,600-7,000
Tetrachloroethylene	3,000-3,800

[1] Milligrams of the compound administered per kilogram body weight of the experimental animal.

Responses to toxic chemicals may differ among individuals because of the physiological variability that is present in the human population. Some individuals, for example, are more likely to experience adverse health effects after exposure to a toxic chemical because of a reduced ability to metabolize that compound. The presence of preexisting medical conditions (e.g., chronic obstructive pulmonary disease (COPD), diabetes, renal disease) can also increase one s susceptibility to toxic chemicals. Respiratory distress in patients or workers with asthma may be triggered by exposure to toxic chemicals at lower levels than might be expected to produce the same effect in individuals without respiratory disease. Factors such as age, personal habits (e.g., smoking, diet), previous exposure to toxic chemicals, and medications may also increase an individual s sensitivity to toxic chemicals. Therefore, exposure to concentrations of toxic compounds that would not be expected to result in the development of a toxic response in most individuals may cause an effect in susceptible individuals. Not all chemicals, however, have a threshold level. Some carcinogens (cancer-causing chemicals) may produce a response (tumors) at any dose level, and any exposure to these compounds may be associated with some risk of developing cancer. Thus, literature values for levels which are not likely to produce an effect do not guarantee that an effect will not occur.

EMS personnel need a strong knowledge of toxicology principles to assess the degree of hazard in a hazmat incident. Among the key questions to consider are:

- What is the route of exposure and how can further exposure be minimized?
- Do the acute symptoms give clues as to the potential exposure and chronic health effects?

- Is this individual at increased risk because of greater susceptibility: for example, a child or an adult with preexisting health problems?

- Can an exposure dose be estimated and will this help to estimate short- and long-term health effects?

Exposure Limits

The various occupational exposure limits found in the literature or in an MSDS are based primarily on time-weighted average limits, ceiling values, or ceiling concentration limits to which the worker can be exposed without adverse effects. Examples of these are listed in Exhibit II-7A.

The values listed in Exhibit II-7A were established to provide worker protection in occupational settings. Because the settings in which these values are appropriate are quite different than an uncontrolled spill site, it is difficult to interpret how these values should be used by emergency medical personnel dealing with a hazardous materials incident. These values are designed for a healthy adult working population and have limited utility when applied to some of the at risk groups previously mentioned. At best, TLV, PEL, IDLH, and REL values can be used as benchmarks for determining relative toxicity, and perhaps to assist in selecting appropriate levels of personal protective equipment (PPE). Furthermore, these occupational exposure limits are only useful if trained personnel with special detection equipment are available for measuring the levels of toxic chemicals at the spill site. Of the occupational exposure limit values shown in Exhibit II-7A, only the OSHA values are regulatory limits. The ACGIH values are for guidance only and have certain caveats that may or may not affect the usefulness of the values. Some of these conditions are individual susceptibility or aggravation of a preexisting condition. Because of the limitations of PELs and TLVs, special exposure limits have been established. Emergency Response Planning Guidelines (ERPGs), Short-term Public Emergency Guidance Levels (SPEGLs), and Acute Exposure Guidelines (AEGLs, under development by the EPA), have been designed to assist emergency response personnel in making decisions regarding nonworkplace exposure (Exhibit II-7B). Emergency medical personnel responsible for the management of chemically contaminated patients should be familiar with all of these exposure limits because they will be encountered in various documents dealing with patient care or the selection of PPE. Additional expertise can be obtained by taking classes offered by the ACGIH or at many colleges and universities.

This brief discussion highlights some fundamental concepts of toxicology. Emergency medical personnel responsible for managing chemically contaminated patients are encouraged to obtain further training in their recognition and treatment. A list of general toxicology references is provided at the end of this section that will allow emergency medical personnel to undertake a more in-depth examination of the principles of toxicology.

Exhibit II-7A
Occupational Exposure Limits

Value	Abbreviation	Definition
Threshold Limit Value (ACGIH)[1]	TLV	Refers to airborne concentrations of substances and represents conditions under which it is believed that nearly all workers may be repeatedly exposed day after day without adverse effect.
Threshold Limit Value: Time-Weighted Average (ACGIH)[1]	TLV-TWA	The time-weighted average concentration for a normal 8-hour work day and a 40-hour work week, to which nearly all workers may be repeatedly exposed, day after day, without adverse effect.
Threshold Limit Value: Short-Term Exposure Limit (ACGIH)[1]	TLV-STEL	The concentration to which workers can be exposed continuously for a short period of time without suffering from (1) irritation, (2) chronic or irreversible tissue damage, or (3) narcosis of a sufficient degree to increase the likelihood of accidental injury, to impair self-rescue, or to materially reduce work efficiency; and provided that the daily TLV-TWA is not exceeded.
Threshold Limit Value: Ceiling (ACGIH)[1]	TLV-C	The concentration that should not be exceeded during any part of the working exposure.
Permissible Exposure Limit (OSHA)[2]	PEL	Same as TLV-TWA.
Immediately Dangerous to Life and Health (OSHA)[2]	IDLH	A maximum airborne concentration from which one could escape within 30 minutes without any escape-impairing symptoms or any irreversible health effects.
Recommended Exposure Limit (NIOSH)[3]	REL	Highest allowable airborne concentration that is not expected to injure a worker; expressed as a ceiling limit or time-weighted average for an 8- or 10-hour work day.

[1] American Conference of Governmental Industrial Hygienists
[2] Occupational Safety and Health Administration
[3] National Institute for Occupational Safety and Health

Exhibit II-7B
General Population Exposure Limits

Value	Abbreviation	Definition
Emergency Response Planning Guidelines (AIHA)[1]	ERPG	Maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hour without (1) experiencing other than mild transient adverse health effects or perceiving a clearly defined objectionable odor (ERPG-1), (2) experiencing or developing irreversible or other serious health effects or symptoms that could impair an individual s ability to take protective action (ERPG-2), or (3) experiencing or developing life-threatening health effects (ERPG-3).
Short-term Public Emergency Guidance Level (NRC)[2]	SPEGL	An acceptable concentration for unpredicted, single, short-term exposure of the general public in emergency situations. May be developed for different exposure periods (e.g., 1, 2, 4, 8, 16, 24 hours).
Acute Exposure Guidelines (EPA NAC/AEGL)[3]	AEGL	Proposed short-term threshold or ceiling exposure value intended for the protection of the general public, including susceptible or sensitive individuals but not those who are hypersusceptible or hypersensitive. Represents the airborne concentration of a substance at or above which it is predicted that the general population (as defined above) could experience (1) notable discomfort (AEGL-1), (2) irreversible or other serious, long-lasting effects or impaired ability to escape (AEGL-2), or (3) life-threatening effects or death (AEGL-3). Developed for four exposure periods: 30 minutes, and 1, 4 , and 8 hours. Synonymous with the NAS[4] term, Community Emergency Exposure Levels (CEELs).

[1] American Industrial Hygiene Association
[2] National Research Council
[3] EPA National Advisory Committee/AEGL Committee
[4] National Academy of Sciences

Personnel Protection and Safety Principles

This section provides emergency medical services personnel with information on protective equipment and safety principles. In the majority of cases, however, EMS staff will not experience incidents involving chemically contaminated patients frequently enough to keep them optimally trained or their equipment properly maintained. Staff must be trained initially in the proficient use of personal protective equipment (PPE), specifically respiratory equipment, and must maintain that proficiency. According to state and federal regulations, equipment must be maintained according to OSHA specifications; for example, respirators and their cartridges have to be properly fitted, tested, and stored. Many EMS agencies, given their workload and fiscal constraints, may not be able to expend the funds and time necessary to provide the highest level of PPE protection for their employees. EMS personnel should, at a minimum, be prepared to work in Level C attire (see below, *Levels of Protection*). In cases where EMS personnel have no PPE, they should make arrangements with the local fire department or hazmat team to be ready, if the situation warrants, to completely decontaminate patients, especially those who are to be transported to a hospital. Considerations in determining what an EMS s capabilities should be include the number of incidents occurring locally (several per week versus only a few per year), proximity to industries or transportation routes that have the potential for a hazardous materials incident (see Section I SARA Title III), and risks posed from terrorism.

Federal Regulations Pertaining to Use of Personal Protective Equipment (PPE)

The term personal protective equipment (PPE) is used in this document to refer to both clothing and equipment. The purpose of PPE is to shield or isolate individuals from the chemical, physical, and biological hazards that may be encountered at a hazardous materials incident.

Training is essential before any individual attempts to use PPE. OSHA standards mandate specific training requirements (8 hours of initial training or sufficient experience to demonstrate competency) for personnel engaged in emergency response to hazardous substances incidents at the First Responder Operations Level. In addition, each agency must develop a health and safety program and provide for emergency response. These standards also are intended to provide particular protection for those who respond to hazardous materials incidents, such as firefighters, police officers, and EMS personnel. OSHA s final rule (March 6, 1989, 29 CFR (1910.120)) as it applies to emergency medical personnel states: Training shall be based on the duties and functions to be performed by each responder of an emergency response organization.

No single combination of protective equipment and clothing is capable of protecting against all hazards. Thus, PPE should be used in conjunction with other protective methods. The use of PPE can itself create significant worker hazards, such as heat stress, physical and psychological stress, and impaired vision, mobility, and communication. In general, the greater the level of PPE protection, the greater are the associated risks. For any given situation, equipment and clothing should be selected that provide an adequate level of protection. Excessive protection can be as hazardous as under-protection, and should be avoided. In addition, personnel should not be expected to use PPE without adequate training.

The two basic objectives of any PPE program are to protect the wearer from safety and health hazards and to prevent injury to the wearer from incorrect use and/or malfunction of the PPE. To accomplish these goals, a comprehensive PPE program should include: (1) hazard identification; (2) medical monitoring; (3) environmental surveillance; (4) selection, use, maintenance, and decontamination of PPE; and (5) training.

PPE Complications

Personnel wearing PPE are likely to encounter a number of potential problems, including limited visibility, reduced dexterity, claustrophobia, restricted movement, suit breach, insufficient air supply, dehydration, and the effects of heat and cold. Only individuals who are physically fit and have met the OSHA/NIOSH/NFPA training requirements should be wearing PPE during an incident. Proper donning and doffing procedures must be followed, with assistance from other onsite personnel. Medical surveillance evaluations should be conducted on all personnel both before and immediately after their use of PPE. Personnel not meeting prescribed inclusion criteria set by the hazmat team or by the EMS Medical Director should be reassigned to an area not requiring the use of PPE. The actions of all personnel wearing PPE should be closely observed by the Safety Officer and others during each work period. In addition, an emergency distress signal should be identified in the briefing before individuals enter the work area. Following the completion of technical decontamination, all personnel should be examined to ascertain marked changes in health. Appropriate medical care should be initiated when illness or injury is discovered.

Levels of Protection

EPA has designated four levels of protection to assist in determining which combinations of respiratory protection and protective clothing should be employed:

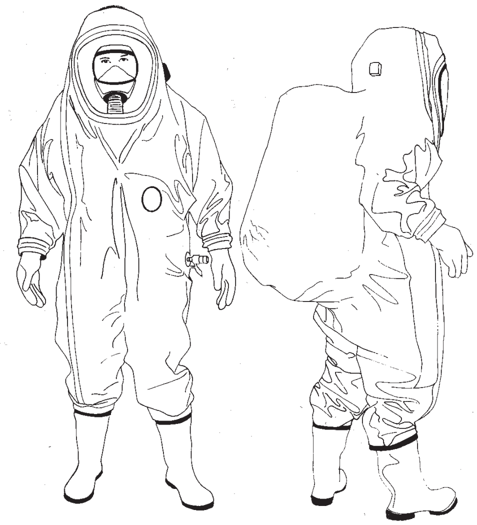
Level A protection should be worn when the highest level of respiratory, skin, eye, and mucous membrane protection is needed. It consists of a fully-encapsulated, vapor-tight, chemical-resistant suit, chemical-resistant boots with steel toe and shank, chemical-resistant inner/outer gloves, coveralls, hard hat, and self-contained breathing apparatus (SCBA).

Level B protection should be selected when the highest level of respiratory protection is needed, but a lesser degree of skin and eye protection is required. It differs from Level A only in that it provides splash protection through use of chemical-resistant clothing (overalls and long-sleeved jacket, two-piece chemical splash suit, disposable chemical-resistant coveralls, or fully- encapsulated, non-vapor-tight suit and SCBA).

Level C protection should be selected when the type of airborne substance(s) is known, concentration is measured, criteria for using air-purifying respirators are met, and skin and eye exposures are unlikely. This involves a full facepiece, air-purifying, canister-equipped respirator and chemical-resistant clothing. It provides the same degree of skin protection as Level B, but a lower level of respiratory protection.

Level D is primarily a work uniform. It provides no respiratory protection and minimal skin protection, and it should not be worn on any site where respiratory or skin hazards exist.

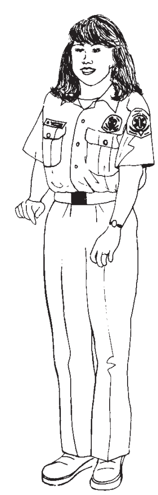
Exhibit II-8 illustrates these four levels of protection. For more information on this subject, Appendix C outlines the protective equipment recommended for each level of protection.



Level A

Level B

Level C



Level D

Exhibit II-8
Levels of Protection

Factors to be considered in selecting the proper level of protection include the potential routes of entry for the chemical(s), the degree of contact, and the specific task assigned to the user. Activities can also be undertaken to determine which level of protection should be chosen. The EPA and NIOSH recommend that initial entry into unknown environments or into a confined space that has not been chemically characterized be conducted wearing at least Level B, if not Level A**,** protection.

Routes of Entry

PPE is designed to provide emergency medical personnel with protection from hazardous materials that can affect the body by one of three primary routes of entry: inhalation, ingestion, and direct contact. *Inhalation* occurs when emergency personnel breathe in chemical fumes or vapors. Respirators are designed to protect the wearer from contamination by inhalation but they must be worn properly and fit-tested frequently to ensure continued protection. *Ingestion* usually is the result of a health care provider transferring hazardous materials from his hand or clothing to his mouth. This can occur unwittingly when an individual wipes his mouth with his hand or sleeve, eats, drinks, or smokes tobacco. *Direct contact* refers to chemical contact with the skin or eye. Skin is protected by garments, and full-face respirators protect against ingestion and direct eye contact. Mucous membranes in the mouth, nose, throat, inner ear, and respiratory system may be affected by more than one of these routes of entry. Many hazardous materials adhere to and assimilate with the moist environment provided by these membranes, become trapped or lodged in the mucus, and are subsequently absorbed or ingested.

Chemical Protective Clothing (CPC)

Protective clothing is designed to prevent direct contact of a chemical contaminant with the skin or body of the user. There is, however, no one single material that will afford protection against all substances. As a result, multilayered garments may be employed in specific situations despite their negative impact on dexterity and agility. CPC is designed to afford the wearer a known degree of protection from a known type, a known concentration, and a known length of exposure to a hazardous material, but only if it is properly fitted and worn correctly. Improperly used equipment can expose the wearer to danger. Another factor to keep in mind when selecting CPC is that most protective clothing is designed to be impermeable to moisture, thus limiting the transfer of heat from the body through natural evaporation. This is a particularly important factor in hot environments or for strenuous tasks since such garments can increase the likelihood of heat-related injuries. Research is now underway to develop lightweight suits that are breathable but still protective against a wide range of chemicals. Cooling vests are sometimes used in warm weather situations to keep the body temperature normal, but with mixed results.

Essential to any protective ensemble are chemical resistant boots with steel toe and shank. Chemical resistant inner and outer layered gloves must also be worn. Compatibility charts should be consulted to determine the appropriate type of boot and gloves to use, since no one material presently provides protection against all known chemicals. Wearing multiple layers of gloves impairs dexterity and makes performing basic aspects of patient assessment (e.g., checking breathing, taking a pulse) difficult without constant practice.

The effectiveness of CPC can be reduced by three actions: degradation, permeation, and penetration. *Chemical degradation* occurs when the characteristics of the material in use are altered through contact with chemical substances or aging. Examples of degradation include cracking and brittleness, and other changes in the structural characteristics of the garment. Degradation can also result in an increased permeation rate through the garment.

Permeation is the process by which chemical compounds cross the protective barrier of CPC because of passive diffusion. The rate at which a compound permeates CPC is dependent on factors such as the chemical properties of the compound, the nature of the protective barrier in the CPC, and the concentration of the chemical on the surface of the protective material. Most CPC manufacturers provide charts on the breakthrough time the time it takes for a chemical to permeate the material of a protective suit for a wide range of chemical compounds.

Penetration occurs when there is an opening or a puncture in the protective material. These openings can include unsealed seams, buttonholes, and zippers. Often such openings are the result of faulty manufacture or problems with the inherent design of the suit.

Protective clothing is available in a wide assortment of forms, ranging from fully-encapsulated body suits to gloves, hard hats, earplugs, and boot covers. CPC comes in a variety of materials, offering a range of protection against a number of chemicals. Emergency medical personnel must evaluate the properties of the chemical versus the properties of the protective material. Selection of the appropriate CPC will depend on the specific chemical(s) involved, and on the specific tasks to be performed.

Respiratory Protection

Substantial information is available for the correct selection, training, and use of respirators. The correct respirator must be employed for the specific hazard in question. Material Safety Data Sheets (if available) often specify the type of respirator that will protect users from risks. In addition, manufacturers suggest the types of hazards against which their respirators can offer protection. OSHA has set mandatory legal minimum requirements (29 CFR (1910.134)) for respiratory protection. In addition, NIOSH has established comprehensive requirements for the certification of respiratory protection equipment.

Personnel must be fit-tested for use of all respirators. Even a small space between the respirator and you could permit exposure to a hazardous substance(s) by allowing in contaminated air. Anyone attempting to wear any type of respirator must be trained and drilled in its proper use. Furthermore, equipment must be inspected and checked for serviceability on a routine basis.

There are two basic types of respirators: air-purifying and atmosphere-supplying. Atmosphere-supplying respirators include self-contained breathing apparatus (SCBA) and supplied-air respirators (SAR).

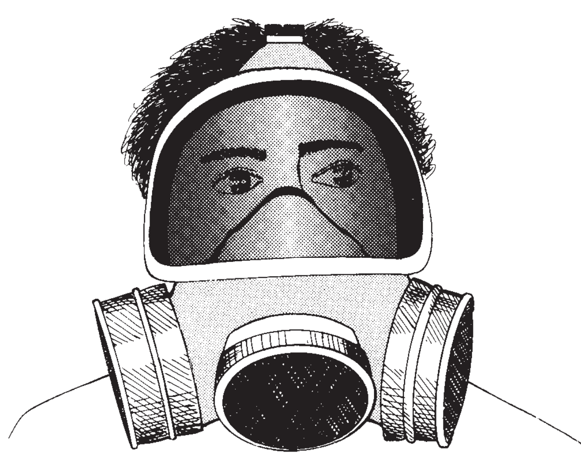
Air-Purifying Respirators (APRs)

An air-purifying respirator purifies ambient air by passing it through a filtering element before inhalation. The major advantage of the APR system is the increased mobility it affords the wearer. However, a respirator can only be used where there is sufficient oxygen (19.5 percent) since it depends on ambient air to function. In addition, APRs should not be used when substances with poor warning properties are known to be involved or, if the agent is unknown, when environmental levels of a substance exceed the filtration capacity of the canisters.

Three basic types of APRs are used by emergency personnel: chemical cartridges or canisters, disposables, and powered air-purifiers. The most commonly used APR depends on *cartridges* (Exhibit II-9) or *canisters* to purify the air by chemical reaction, filtration, adsorption, or absorption. Cartridges and canisters are designed for specific materials at specific concentrations. To aid the user, manufacturers have color-coded the cartridges and canisters to indicate the chemical or class of chemicals for which the device is effective. NIOSH recommends that use of a cartridge not exceed one work shift. However, if breakthrough of the contaminant occurs first, then the cartridge or canister must be immediately replaced. After use, cartridges and canisters should be considered contaminated and disposed of accordingly.

Disposable APRs are usually designed for use with particulates, such as asbestos, although some are approved for use with other contaminants. These respirators are typically half-masks that cover the face from nose to chin, but do not provide eye protection. Once used, the entire respirator is usually discarded. This type of APR depends on a filter to trap particulates. Filters may also be used in combination with cartridges and canisters to provide an individual with increased protection from particulates. The use of half-mask APRs is not generally recommended by most emergency response organizations.

Exhibit II-9
Chemical Cartridge Air-Purifying Respirator

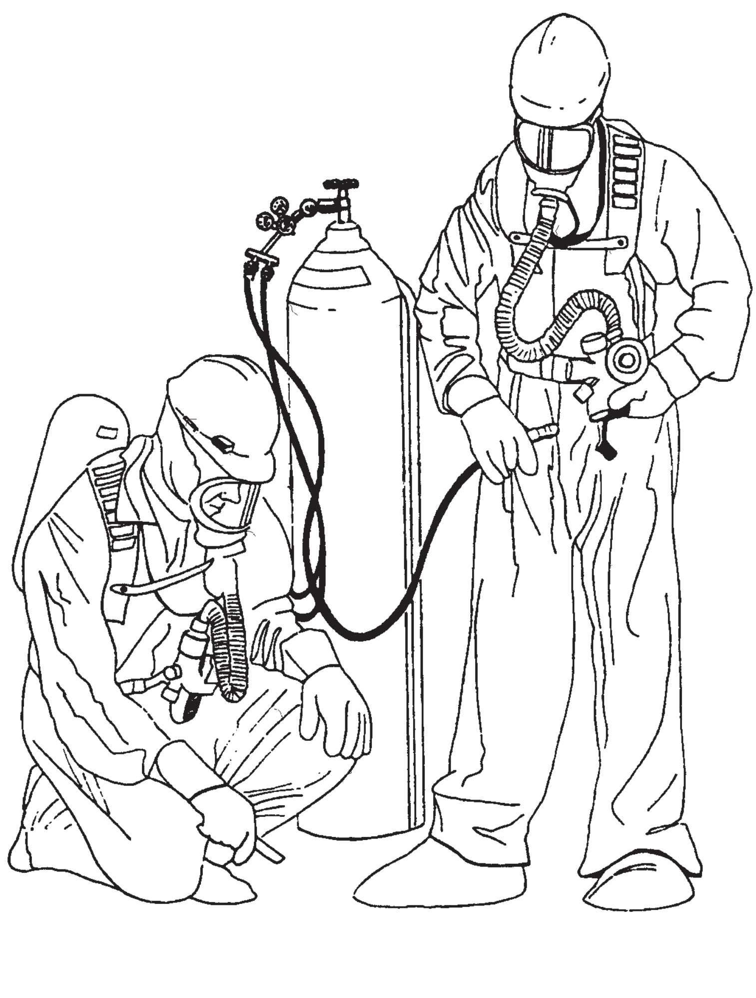


Powered Air-Purifying Respirators (PAPRs) have the advantage of creating an improved facemask seal, thus reducing the risk of inhalation injury. Air being blown into the mask can also have a cooling affect. PAPRs come with either full facemasks or pullover hoods. Some individuals find the hooded system to be more comfortable and less claustrophobic than the mask. According to OSHA guidelines, men with beards can wear the hooded system but not the full facemask.

Atmosphere-Supplying Respirators

Atmosphere-supplying respirators consist of two basic types: the self-contained breathing apparatus (SCBA), which contains its own air supply, and the supplied-air respirator (SAR), which depends on an air supply provided through a line linked to a distant air source. Exhibit II-10 illustrates an example of each.

Exhibit II-10
Self-Contained Breathing Apparatus and Supplied-Air Respirators



Self-Contained Breathing Apparatus (SCBA)

A self-contained breathing apparatus respirator is composed of a facepiece connected by a hose to a compressed air source. There are three varieties of SCBAs: open-circuit, closed-circuit, and escape. Open-circuit SCBAs, most often used in emergency response, provide clean air from a cylinder to the wearer, who exhales into the atmosphere. Closed-circuit SCBAs, also known as rebreathers, recycle exhaled gases and contain a small cylinder of oxygen to supplement the exhaled air of the wearer. Escape SCBAs provide air for a limited amount of time and should only be used for emergency escapes from a dangerous situation. One disadvantage of SCBAs is that they are bulky and heavy, and can be used for only the period of time allowed by air in the tank.

The most common SCBA is the open-circuit, positive-pressure type. In this system, air is supplied to the wearer from a cylinder and enters the facepiece under positive pressure. In contrast to the negative-pressure units, a higher air pressure is maintained inside the facepiece than outside. This affords the SCBA wearer the highest level of protection against airborne contaminants since any leakage in the facepiece may force the contaminant out. When wearing a negative-pressure-type apparatus, there is always the potential danger that contaminants may enter the facemask if it is not properly sealed. The use of a negative-pressure SCBA is prohibited by OSHA under 29 CFR (1910.120(q)(iv)) in incidents where personnel are exposed to hazardous materials.

Supplied-Air Respirators (SARs)

Supplied-air respirators differ from SCBAs in that the air is supplied through a line that is connected to a source away from the contaminated area. SARs are available in both positive- and negative-pressure models. However, only positive-pressure SARs are recommended for use at hazardous materials incidents. One major advantage the SAR has over the SCBA device is that it allows an individual to work for a longer period. In addition, SARs are less bulky than the SCBAs. By necessity, however, a worker must retrace his steps to stay connected to the SAR, and therefore cannot leave the contaminated work area by a different exit. SARs also require the air source to be in close proximity (within 300 feet) to the work area. In addition, personnel using an SAR must carry an immediately operable emergency escape supply of air, usually in the form of a small, compressed air cylinder, for use in case of an emergency.

Site Control

Hazardous materials incidents often attract large numbers of people and equipment. This complicates the task of minimizing risks to humans, property, and the environment.

An Incident Command System (ICS) coordinates management of facilities, equipment, personnel, and communications during a hazardous materials incident. An Incident Commander (IC) is responsible for control of the scene and for keeping contaminants on site. This includes delineating work zones, establishing levels of protection, and implementing decontamination activities.

To enhance control at the site of a chemical incident, rules regarding access to the site must be implemented. Inactive individuals and equipment should be kept at a safe distance from the area of possible contamination, and public access from all directions must be restricted promptly.

In addition, media access should be limited to an area established as the Public Information Sector by a designated Public Information Officer. All access to the incident site must be approved by the Incident Commander and the press personnel who enter the site must be escorted by a Public Information Officer.

Work Zones

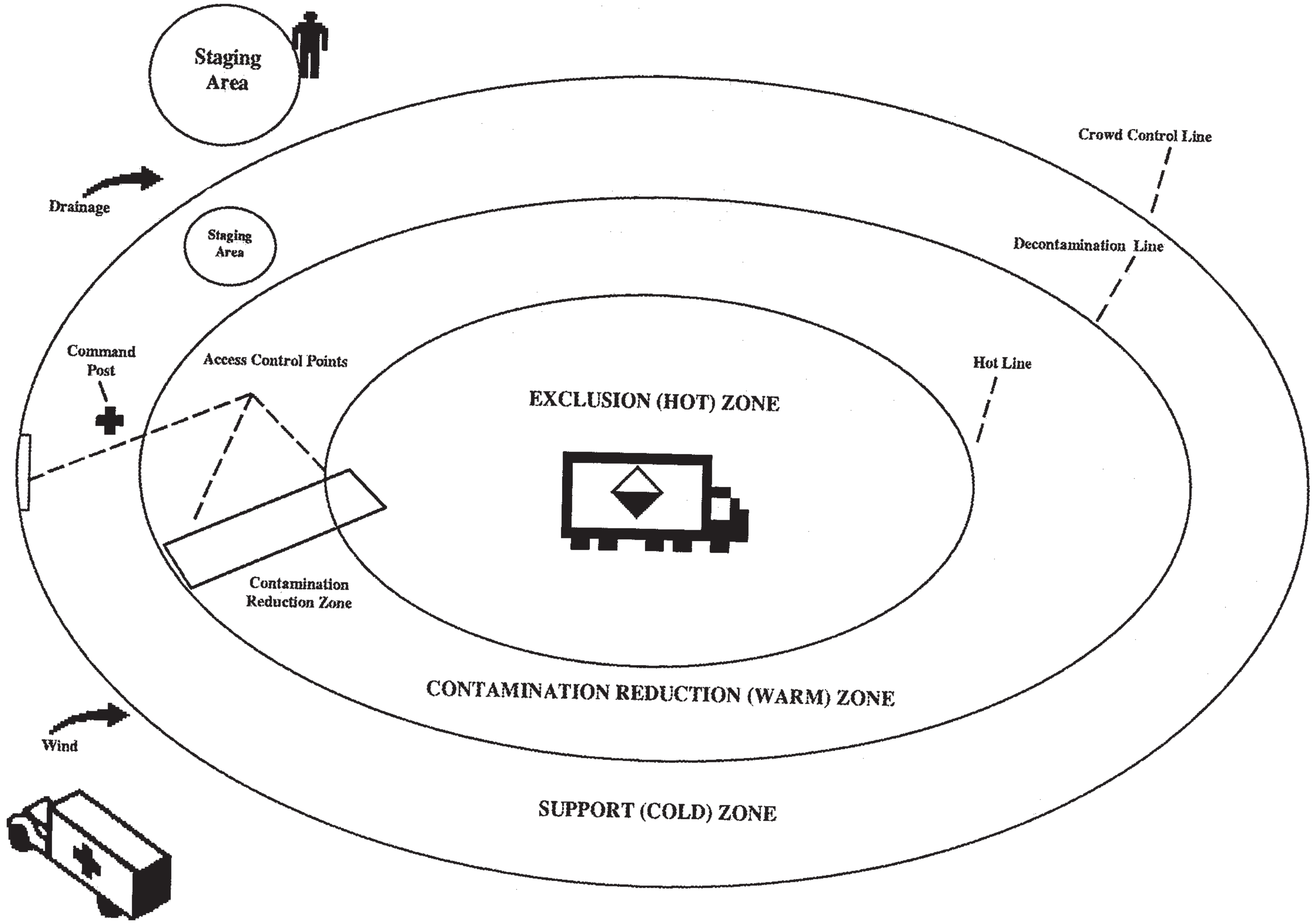
NIOSH, OSHA, USCG, and EPA recommend dividing the incident area into three zones, establishing access control points, and delineating a contamination reduction corridor. Exhibit II-11 illustrates the recommended zones. The Exclusion (Hot) Zone should encompass all known or suspected hazardous materials contamination. The respective radius of the Contamination Reduction (Warm) Zone is determined by the length of the decontamination corridor, which contains all of the needed decontamination stations. The Support (Cold) Zone should be clean, meaning it is free of all hazardous materials contamination, including discarded protective clothing and respiratory equipment. The command post and staging areas for necessary support equipment should be located in the Support Area, upwind and uphill of the Exclusion Zone. Personnel in charge of each sector should be easily recognized (e.g., with a command vest). Equipment that may eventually be needed should be kept in staging areas beyond the crowd control line. Access to the different zones should be tightly controlled and limited to as few people as possible. Communication between work areas should be face-to-face whenever possible. Use of radios or other electronic devices (e.g., bullhorns) may be restricted depending on the hazards involved.

Decontamination of Emergency Medical Service Personnel

Decontamination is the process of removing or neutralizing harmful materials that have gathered on personnel and/or equipment during the response to a chemical incident. Many incidents have occurred involving seemingly successful rescue, transport, and treatment of chemically contaminated individuals by unsuspecting emergency personnel who, in the process, contaminate themselves, the equipment, and the hospital where the patient is taken. Decontamination is of the utmost importance because it:

- Protects all hospital personnel by sharply limiting the transfer of hazardous materials from the contaminated area into clean zones.
- Protects the community by preventing transportation of hazardous materials from the hospital to other sites in the community by secondary contamination.
- Protects workers by reducing the contamination and resultant permeation of, or degradation to, their protective clothing and equipment.
- Protects other patients already receiving care at the hospital.

Exhibit II-11
NIOSH/OSHA/USCG/EPA Recommended Zones



This section only addresses the steps necessary for dealing with worker decontamination. Patient decontamination is addressed in Section III, *Response and Patient Management*. It should be stressed that to carry out proper decontamination, personnel must have received at least the same degree of training as required for workers who respond to hazardous materials incidents. The design of the decontamination process should take into account the degree of hazard and should be appropriate for the situation. For example, a nine-station decontamination process need not be set up if only a bootwash station would suffice.

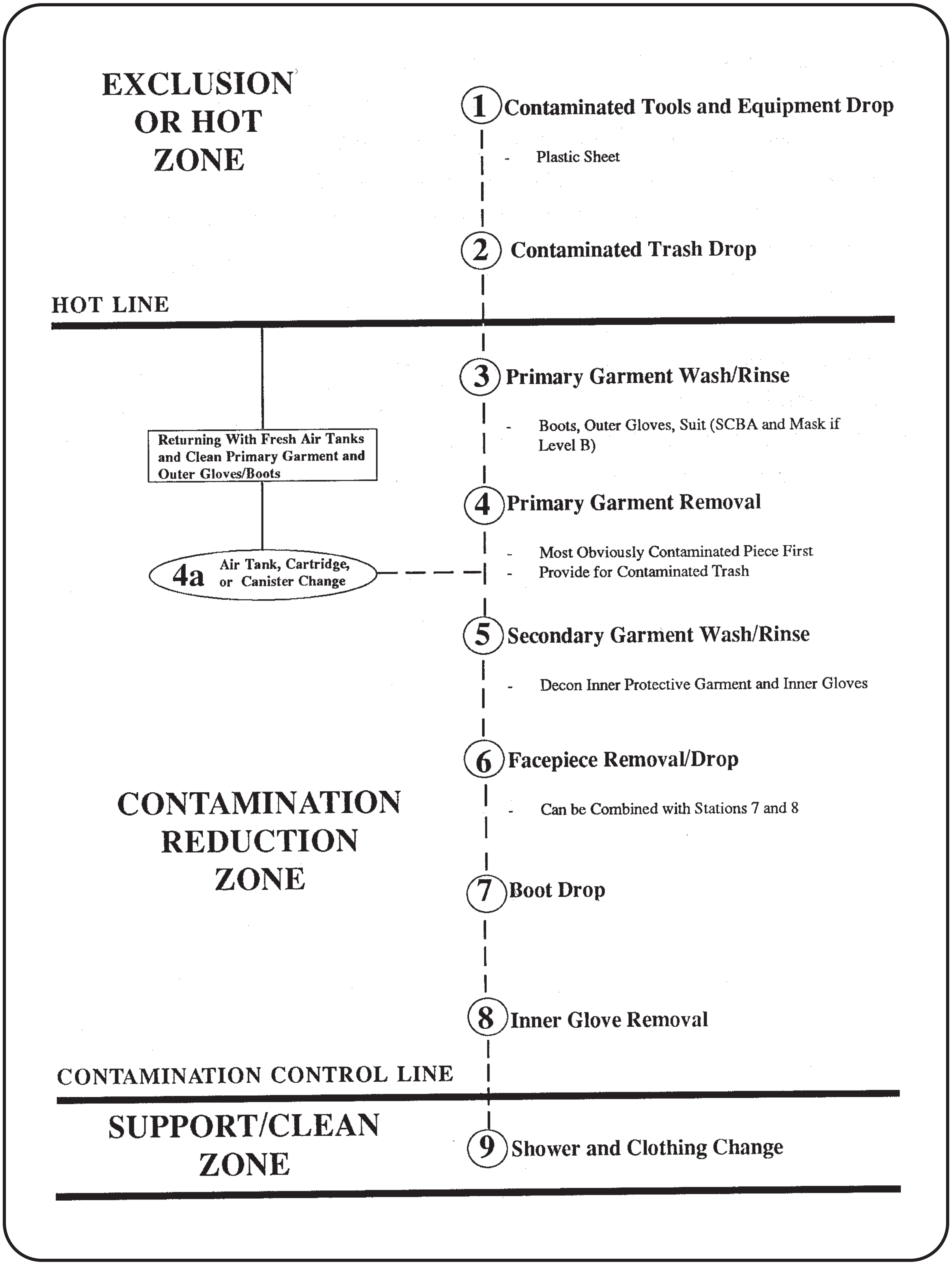
Avoiding contact is the easiest method of decontamination that is, not to get the material on the worker or his protective equipment in the first place. However, if contamination is unavoidable, then proper decontamination and/or disposal of the worker s outer gear will be necessary. Segregation and proper placement of the outer gear in a polyethylene bag or steel drum will be necessary until thorough decontamination is completed. With extremely hazardous materials, it may be necessary to dispose of the contaminated items altogether.

Physical decontamination of protective clothing and equipment (known as technical decontamination) can be achieved by several different means. These all include the systematic removal of contaminants by physical methods, such as dilution, brushing, scraping, and vacuuming, and by chemical methods where the contaminant is degraded, neutralized, solidified, or disinfected through some type of chemical process. There is an increasing trend toward using disposable clothing (e.g., suits, boots, gloves) and systematically removing these garments in a manner that precludes contact with the contaminants. The used items of clothing are then thrown away in a sealed container. Reusable suits will require thorough cleaning and testing after each use. The appropriate decontamination procedure will depend on the contaminant and its physical properties, and on the type of CPC being worn. Thoroughly researching the chemicals involved and their properties, or consultation with an expert, is necessary to make these kinds of decisions.

In addition to understanding the technical decontamination steps to be used for CPC and equipment, EMS responders must be familiar with the emergency procedures to be followed if a responder wearing PPE becomes ill or is injured and needs to be quickly decontaminated prior to normal removal of his suit.

Care must be taken at all times to ensure that the decontamination methods being used do not introduce fresh hazards into the situation. In addition, the residues of the decontamination process must be treated as hazardous wastes. The decontamination stations and process should be confined to the Contamination Reduction Zone (see Exhibit II-11). Steps for personnel decontamination are outlined in Exhibit II-12, and the technical decontamination process is discussed below.

Exhibit II-12
Nine-Step Personnel Decontamination Plan



Technical Decontamination Process for EMS Personnel

Personnel should remove protective clothing in the following sequence.

1. **Remove tape (if used) securing gloves and boots to suit.**
2. **Remove outer gloves, turning them inside out as they are removed.**
3. **Remove suit, turning it inside out and folding it downward. Avoid shaking.**
4. **Remove boot/shoe cover from one foot and step over the clean line. Remove other boot/shoe cover and put that foot over the clean line.**
5. **Remove mask. The last person removing his/her mask may want to wash all masks with soapy water before removing his/her suit and gloves. Place the masks in plastic bag and hand the bag over the clean line for placement in second bag held by another staff member. Send bag for decontamination.**
6. **Remove inner gloves and discard them in a drum inside the dirty area.**
7. **Secure the dirty area until the level of contamination is established and the area is properly cleaned.**
8. **Personnel should then move to a shower area, remove undergarments and place them in a plastic bag. Double-bag all clothing and label bags appropriately.**
9. **Personnel should shower and redress in normal working attire and then report for medical surveillance.**

Communications

Effective communications are essential to maintaining incident control. These include a dedicated radio frequency and a sufficient number of radios for distribution to all participating agencies. Another network should link the onsite command post to support groups, such as the regional Poison Control Center, the Health Department, and CHEMTREC. Other networks that may have to be activated include one linking EMTs to the hospital emergency department or medical control and one dedicated for use by the teams in the Exclusion and Contamination Reduction Zones. If a sufficient number of radios are not available or cannot be used in the Exclusion Zone, then line of sight must be maintained at all times for personnel in those Zones. Use of whiteboards, PA systems, or designated hand signals may be useful alternatives. When an Incident Command System is activated, one person should be assigned to manage communications.

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