Section I. Emergency Department Response to Hazardous Materials Incidents

HAZARD RECOGNITION

When dispatched to the scene of an incident, emergency response personnel may not be aware that the incident involves hazardous materials. As a result, emergency department personnel should always be alert to the possibility that they may be dealing with a chemically contaminated individual, and should ask incident victims and dispatch personnel about the nature of the incident. Emergency departments should also be prepared for exposed patients that arrive unannounced by privately owned vehicles miles away from an incident site. Although an injury at a hazardous materials incident need not invariably involve a chemical exposure (it could have resulted from a purely physical occurrence, such as slipping off a ladder), as a routine precaution, the involvement of hazardous materials should be considered a possibility in such situations. As outlined in the National Fire Academy/National Emergency Training Center Manual, Recognizing and Identifying Hazardous Materials, there are six clues that may confirm the presence of hazardous materials. These clues are included in this guidance document to facilitate and expedite prompt identification of any hazardous materials at the scene of the incident. Hospital emergency department personnel, familiar with these clues, will subsequently find the communication with field personnel enhanced. For example, patient symptoms reported from the field—such as nausea, dizziness, itching/burning eyes or skin, or cyanosis—could suggest to the hospital staff the presence of hazardous materials. Knowledgeable hospital staff could then request field personnel to examine the site for these six clues:

- **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 hazardous materials — for example laboratories, factories, farm and paint supply outlets, and construction sites.

- **Container Shape**. Department of Transportation (DOT) regulations specify container specifications for 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 can vary in shape depending upon the cargo; and smaller quantities of hazardous materials that may be packaged in fiberboard boxes, drums, or cylinders with labeling. Often the shape and configuration of the container can be a useful clue to the presence of hazardous materials.

- **Markings/Colors**. 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. A marking system designed by the National Fire Protection Association (NFPA) identifies hazardous 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 consideration: 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. In addition, a number from zero through four indicates the relative risk of the hazard with zero being the minimum risk.

- **Placards/Labels**. These convey information by use of colors, symbols, Hazard Communication Standard, 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 in bulk, such as in cargo tanks; labels designate hazardous materials on small packages.

- **Shipping Papers**. These can clarify what is labeled "dangerous" on placards. They should provide the shipping name, hazard class, ID number, and quantity and may indicate "waste" or "poison." (Shipping papers must accompany all hazardous material shipments.)

- **Senses**. Odor, vapor clouds, dead animals or dead fish, fire, and irritation to skin or eyes can signal the presence of hazardous materials. Generally, if one detects the odor of hazardous materials, one should assume that exposure has occurred. Some chemicals, however, can impair an individual's sense of smell (i.e., hydrogen sulfide), and others have no odor at all (i.e., carbon monoxide).

Appendix A provides illustrations and greater detail on the National Fire Protection Association 704M system, the Department of Transportation hazardous materials marking, labeling, and placarding guide, and the Department of Labor Material Safety Data Sheet (MSDS). It is important that any and all available clues are used in the process of substance identification, especially the most obvious, such as the information provided on a label or in shipping papers (NOTE: shipping papers should remain at the incident scene for use by other response personnel). The aim of the health provider should be to make a product-specific identification. Every effort should be taken to prevent exposure to chemicals. Identifying the hazardous material and obtaining information on its physical characteristics and toxicity are steps that are vital to the 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 involved in the incident allows the emergency responders and emergency department staff to initiate appropriate scene management steps.

Many printed resources are available to provide information concerning response and planning for hazardous materials incidents. A selected bibliography is included at the end of each section; however, this is not a complete list of the materials available. Printed reference materials provide several advantages: they are readily available, can be transported in the response vehicle, are not dependent on a power source or subject to malfunction, and are relatively inexpensive. Disadvantages include the difficulty in determining a correct identity for an unknown chemical, materials are often out of date and cannot be easily updated, and no single volume is capable of providing all the information that may be needed.

There is also a vast array of telephone and computer-based information sources concerning hazardous materials. They can help you by describing the toxic effects of the chemical, its relative potency, and the potential for secondary contamination and by recommending decontamination procedures. They may also provide advice on the adequacy of specific types of protective gear. Exhibit I-1 is a partial listing of the many information resources available by telephone. Exhibit I-1A is a list of suggested telephone numbers that should be filled in for your community. Planning is an essential part of every response, and these resources will also provide guidance that can be used in forming an effective response plan. Exhibit I-2 provides a partial listing of the available computerized and on-line information sources. It should be noted that not all on-line databases are peer reviewed. Therefore, some medical management information may be based only on DOT or MSDS data. Care and planning should be used when selecting information sources

Computerized information sources are basically two types: (a) call-up systems that are addressed via telephone lines and (b) database systems that are housed on a local computer disc. Each system contains large amounts of information on many hazardous materials and can be searched to help identify the material involved. They are updated frequently at no extra cost to the subscriber and are extremely portable with today's computer systems. Computer databases can be expensive, as can the initial cost of the equipment. Most systems will require the operator to have some knowledge of computer terms and search protocols. Also, mechanical equipment may fail and should not be counted on as a sole source of information

Exhibit I-1
Telephone Information and Technical Support References

Resource	Contact	Services Provided
CHEMTREC (Chemical Transportation Emergency Center)	1-800-424-9300	24-hour emergency number. Connection with manufacturers and/or shippers who will provide advice on handling, rescue gear needed, decontamination considerations, etc. Also provides access to Chlorine Emergency Response Plan (CHLOREP).
ATSDR (Agency for Toxic Substances and Disease Registry)	1-404-639-0615	24-hour emergency number for health-related support in hazardous materials emergencies, including on-site assistance, if necessary.
Bureau of Explosives	1-202-639-2222	24-hour emergency number for hazardous materials incidents involving railroads.
Emergency Planning and Community Right-to-Know Information Hotline	1-800-535-0202	8:30 a.m.-7:30 p.m. (EST) Provides information on SARA Title III. Provides list of extremely hazardous substances and planning guidelines.
EPA (Environmental Protection Agency) Regional Offices	Region I - (617) 565-3698 CT, ME, MA, NH, RI, VT Region II - (212) 264-0504 NJ, NY, PR, VI Region III - (215) 597-0980 DE, DC, MD, PA, VA, WV Region IV - (404) 347-3454 AL, FL, GA, KY, MS, NC, SC, TN Region V - (312) 886-7579 IL, IN, MI, MN, OH, WI Region VI - (214) 655-6760 AR, LA, NM, OK, TX Region VII - (913) 236-2850 IA, KS, MO, NE Region VIII - (303) 293-1720 CO, MT, ND, SD, UT, WY Region IX - (415) 974-7460 AM SAMOA, AZ, CA, GU, HI, NV, Trust Territory of the Pacific Isl., Marshall Isl., Palau, Ponape Region X - (206) 442-2782 AK, ID, OR, WA	Environmental response team available for technical assistance.
National Animal Poison Control Center	1-217-333-3611	24-hour consultation concerning animal poisonings or chemical contamination. Provides an emergency response team to investigate incidents and perform laboratory analysis.
National Response Center	1-800-424-8802	For reporting transportation incidents where hazardous materials are responsible for death, serious injury, property damage in excess of $50,000, or continuing danger to life and property.

Exhibit I-1A
Local Telephone Information and Technical Support Resource Worksheet

Resource	Contact (fill in for future reference)	Services Provided (fill in for future reference)
EPA Regional Office		
Regional Poison Control Center		
State Emergency Response Commission		
State Health Department		
Community Fire Department		
Community Police Department		
Local Emergency Planning Committee		
Local Health Department		
State Department of Natural Resources		

Exhibit I-2
Computerized Data Sources of Information and Technical Support

Data System	Contact	Description
ANSWER	ANSWER Specialized Information Svcs National Library of Medicine Building 38A 8600 Rockville Pike Bethesda, Maryland 20894 (301) 496-6531	National Library of Medicine's Workstation for Emergency Response (ANSWER) -- to advise emergency response health professionals on potential hazardous chemical emergencies.
CAMEO	CAMEO Database Manager National Oceanic and Atmospheric Administration (NOAA) Hazardous Materials Response Branch, N/OMA-34 7600 Sand Point Way, N.E Seattle, Washington 98115 (206) 526-6317	Computer-Aided Management of Emergency Operations available to on-scene responder -- Chemical identification database assists in identifying substance involved, predicting downwind concentrations, providing response recommendations, and identifying potential hazards.
CHRIS	CIS, Inc. Fein Management Associates 7215 York Road Baltimore, Maryland 21212 (800) 247-8737	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. 660 Bannock Street Denver, Colorado 80203-3527 (800) 525-9083	Assists responders dealing with incidents involving hazardous materials such as spills, leaks, and fires Emergency medical treatment and recommendations for initial hazardous response are presented.
HMIS	David W. Donaldson Information Sys. Specialist Dept. of Trans./RSPA/OHMT 400 7th Street, S.W. Washington, D.C. 20590 (202) 366-5869	Hazardous Material Information Systems provides name and emergency phone number of manufacturer, chemical formula, NIOSH number, fire fighting, spill, and leak procedures.
HSDB	Toxicology Data Network (TOXNET) National Library of Medicine Toxicology Information Program 8600 Rockville Pike Bethesda, Maryland 20894 (301) 496-6531	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 I-2 (cont.)
Computerized Data Sources of Information and Technical Support

Data System	Contact	Description
1st MEDICAL RESPONSE PROTOCOLS	Micromedex, Inc. 660 Bannock Street Denver, Colorado 80203-3527 (800) 525-9083	For use in developing training programs and establishing protocols for first aid or initial workplace response to a medical emergency.
MEDITEXT	Micromedex, Inc 660 Bannock Street Denver, Colorado 80203-3527 (800) 525-9083	Provides recommendations regarding the evaluation and treatment of exposure to industrial chemicals.
OHMTADS	CIS, Inc. Fein Management Associates 7215 York Road Baltimore, Maryland 21212 (800) 247-8737	Oil and Hazardous Materials Technical Assistance Data Systems provides effects of spilled chemical compounds and their hazardous characteristics and properties, assists in identifying unknown substances, and recommends procedures for handling and cleanup.
TOMES	Micromedex, Inc. 660 Bannock Street Denver, Colorado 80203-3527 (800) 525-9083	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, HSDB, CHRIS, OHMTADS, and 1st Medical Response Protocols.
TOXNET	Toxicology Data Network (TOXNET) National Library of Medicine Toxicology Information Prog. Bethesda, Maryland 20894 (301) 496-6531	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.

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 the toxicity of the chemical, route of exposure, and the nature and extent of exposure to that substance. In order to better understand potential health effects, emergency department personnel should have an understanding of the basic principles and terminology of toxicology.

Toxicology is the study of the nature, effects, and detection of poisons in living organisms. Some 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 by no means a complete list of toxic end points, but rather a selection of effects that might be encountered (Exhibit I-3).

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

Toxic End Point	Target Organ Systems	Example of Causative Agent	Health Effect	
			Acute	Chronic
Carcinogenicity	Multiple Sites	Benzene	Dermatitis Tightness in Chest	Aleukemia Myeloblastic leukemia
Hepatotoxicity	Liver	Carbon Tetra-chloride	Vomiting Vesication 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

Toxic chemicals often produce injuries at the site at which they come into contact with the body. A chemical injury at the site of contact with the body, typically the skin and the mucous membranes of the eyes, nose, mouth, or respiratory tract, is termed a *local toxic effect.* For example, irritant gases, such as chlorine and ammonia, can produce a localized toxic effect in the respiratory tract; corrosive acids and bases can produce a local damage to the skin. In addition, a toxic chemical may be absorbed into the blood stream and distributed to other parts of the body. These compounds may then produce *systemic effects*. For example, many pesticides are absorbed by the skin, distributed to other sites in the body, and produce adverse effects such as seizures or other neurological 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.

Routes and Extent of Exposure

There are three main *routes of chemical exposure*: inhalation, skin contact, and ingestion. *Inhalation* results in the 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 blood stream because of the large surface area of the lung tissue and number of blood vessels in the lungs. *Skin contact* exposure does not typically result in as rapid systemic dosage as inhalation, although some chemicals are readily absorbed through the skin. Many organic compounds are lipid (fat) soluble and can therefore be rapidly absorbed through the skin. Some materials that come in contact with the eyes can also be absorbed. *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 containing trapped airborne contaminants can cause exposure by this route. In addition, emergency medical personnel in both hospital or prehospital settings will see chemical exposures in patients who have ingested toxic substances as a result of accidental poisonings or suicide attempts.

Compounds can also be introduced into the body by injection; however, injection exposure is an unlikely scenario involving spills or discharges of hazardous materials.

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 following exposure by one route more readily than by another. In addition to the route of exposure, the amount of the compound absorbed by the body depends on the duration of exposure to the compound and the concentration of the compound to which one is exposed. Therefore, 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 medical 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 patient, such as size of the skin surface area exposed, presence of open wounds or breaks in the skin, and rate and depth of respiration, are important in estimating the dose of the compound received by the patient.

Dose-Response Relationship

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

Typically, as the dose increases, the severity of the toxic response increases. For example, 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. Exposure to 1,500 ppm tetrachloroethylene for 30 minutes may result in a loss of consciousness (Exhibit I-5). As shown in Exhibit I-5, the severity of the toxic effect is also dependent on the duration of exposure, a factor that influences the dose of the compound in the body.

Exhibit I-4
Classification of Factors Influencing Toxicity

Type	Examples
1. 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.
2. Factors related to exposure.	Dose; concentration; route of exposure (inhalation, ingestion, etc.); duration.
3. Factors related to person exposed.	Heredity; immunology; nutrition; hormones; age; health status; preexisting diseases; gender.
4. Factors related to environment.	Media (air, water, soil, etc.); additional chemicals present; temperature; atmosphere pressure.

Exhibit I-5
Dose-Response Relationship for Humans Inhaling Tetrachlorothylene Vapors

Levels in Air	Duration of Exposure	Effect 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

Toxicity information is often expressed as the dose of the compound that causes an effect in a percentage of the exposed subjects, which are mostly experimental animals. These dose-response terms are often found in Material Safety Data Sheets (MSDS) and other sources of health information. One dose-response term that is commonly used is the lethal dose 50 (LD_{50}), the dose which is lethal to 50% of an animal population from exposure by any route other than inhalation when given all in one dose. Another 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% of a group of test animals when administered as a single exposure (usually 1 hour). Exhibit I-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 orally to rats.

From Exhibit I-6, it can be seen that a dose of 3,000-3,800 mg/kg tetrachloroethylene is lethal to 50% 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 larger LD_{50} values.

The LD_{50} values that appear in 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. Furthermore, LD_{50} values typically come from experimental animal studies. Because of the anatomical and physiological

Exhibit I-6

Acute LD_{50} Values for Representative Chemicals When Administered Orally to Rats

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

*Milligrams of the compound administered per kilogram body weight of the experimental animal.

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. Therefore, emergency medical personnel should remember that the LD_{50} and LC_{50} values are only useful for comparing the relative toxicity of compounds and should only be used to determine if one chemical is more toxic than another.

Responses to toxic chemicals may differ among individuals because of the physiological variability that is present in the human population. For example, an individual may be more likely to experience an adverse health effect after exposure to a toxic chemical because of a reduced ability to metabolize that compound. The presence of preexisting medical conditions 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 concentrations than might be expected to produce the same effect in individuals without respiratory disease. Factors such as age, personal habits (i.e., smoking, diet), previous exposure to toxic chemicals, and medications may also increase one'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 chemicals that produce cancer (carcinogens) may produce a response (tumors) at any dose level. 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.

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 to without adverse effects. Examples of these are listed in Exhibit I-7.

Exhibit I-7
Occupational Exposure Limits

Value	Abbreviation	Definition
Threshold Limit Value (3 Types) (ACGIH)*	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.
1) Threshold Limit Value — Time-Weighted Average (ACGIH)*	TLV-TWA	The time-weighted average concentration for a normal 8-hour workday and a 40-hour workweek, to which nearly all workers may be repeatedly exposed, day after day, without adverse effect.
2) Threshold Limit Value — Short-Term Exposure Limit (ACGIH)*	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 sufficient degree to increase the likelihood of accidental injury, impair self-rescue or materially reduce work efficiency, and provided that the daily TLV-TWA is not exceeded.
3) Threshold Limit Value — Ceiling (ACGIH)*	TLV-C	The concentration that should not be exceeded during any part of the working exposure.
Permissible Exposure Limit (OSHA)**	PEL	Same as TLV-TWA.
Immediately Dangerous to Life and Health (OSHA)**	IDLH	A maximum concentration (in air) from which one could escape within 30 minutes without any escape-impairing symptoms or any irreversible health effects.
Recommended Exposure Limit (NIOSH)***	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.

* American Conference of Governmental Industrial Hygienists
** Occupational Safety and Health Administration
*** National Institute for Occupational Safety and Health

The values listed in Exhibit I-7 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. At best, TLV, PEL, IDLH, and REL values can be used as a benchmark for determining relative toxicity, and perhaps assist in selecting appropriate levels of Personal Protective Equipment (PPE). Furthermore, these occupational exposure limits are only useful if the appropriate instrumentation is available for measuring the levels of toxic chemicals in the air at the chemical spill site. Of the above occupational exposure limit values, only the OSHA values are regulatory limits. The ACGIH values are for guidance only and are not regulatory limits. In addition, the ACGIH limits 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. Nevertheless, all emergency medical personnel responsible for the management of chemically contaminated patients should be familiar with these concepts because they will be encountered in various documents dealing with patient care or the selection of PPE.

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 recognizing and treating health effects related to chemical exposures. Also, a list of general references in toxicology 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.

Personnel Protection and Safety Principles

This section is designed to provide those emergency medical personnel who may be required to provide care to chemically contaminated patients, because of their proximity to a chemical industrial area or transport corridor, with information on protective equipment and safety principles. However, in the vast majority of cases, hospital staff will not experience a large enough number of cases to keep them optimally trained or their equipment properly maintained. For example, respirators and their cartridges must be properly fitted, tested, and stored. Staff must be initially trained in the proficient use of PPE, specifically respiratory equipment, and must maintain that proficiency. Equipment must be maintained according to OSHA standards. Many hospitals, given their workload mix, may not be able to expend the funds and time necessary to accomplish this task. In these cases, these hospitals should make arrangements with the local fire department or hazardous materials (hazmat) team to be ready, if the situation warrants, to decontaminate patients, including those who are transported to a hospital before they are decontaminated. Considerations in determining what a hospital's capabilities should be include the number of incidents occurring locally (several per week versus only a few per year) and proximity to industries or transportation routes that have a potential for a hazardous materials incident (see Section III — SARA Title III).

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 personal protective 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.

Recent new OSHA standards mandate specific training requirements (8 hours of initial training or sufficient experience to demonstrate competency) for employees engaged in emergency response to hazardous substances incidents at the first responder operations level. Additionally, each employer must develop a safety and health program and provide for emergency response. These standards also are intended to provide additional protection for those who respond to hazardous materials incidents, such as firefighters, police officers, and EMS personnel. OSHA's March 6, 1989, 29 CFR [1910.120] final rule as it applies to emergency medical personnel states that: "Training shall be based on the duties and functions to be performed by each responder of an emergency response organization" (p. 9329).

Training Is Essential Before Any Individual Attempts To Use PPE.

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. Over-protection can be as hazardous as under-protection and should be avoided. Personnel should not be expected to use PPE without adequate training. The two basic objectives of any PPE program should be to protect the wearer from safety and health hazard 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: hazard identification; medical monitoring; environmental surveillance; selection, use, maintenance, and decontamination of PPE; and training.

Levels of Protection

The Environmental Protection Agency (EPA) has assigned 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-encapsulating chemical-resistant suit and self-contained breathing apparatus (SCBA).

- Level B protection should be selected when the highest level of respiratory protection is needed but a lesser level of skin and eye protection is sufficient. It differs from Level A only in that it provides splash protection by use of chemical-resistant clothing (overalls, long sleeves, jacket, and SCBA).

- Level C protection should be selected when the type of airborne substances 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 level of skin protection as Level B, but a lower level of respiratory protection.

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

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

Exhibit I-8
Levels of Protection

Level A

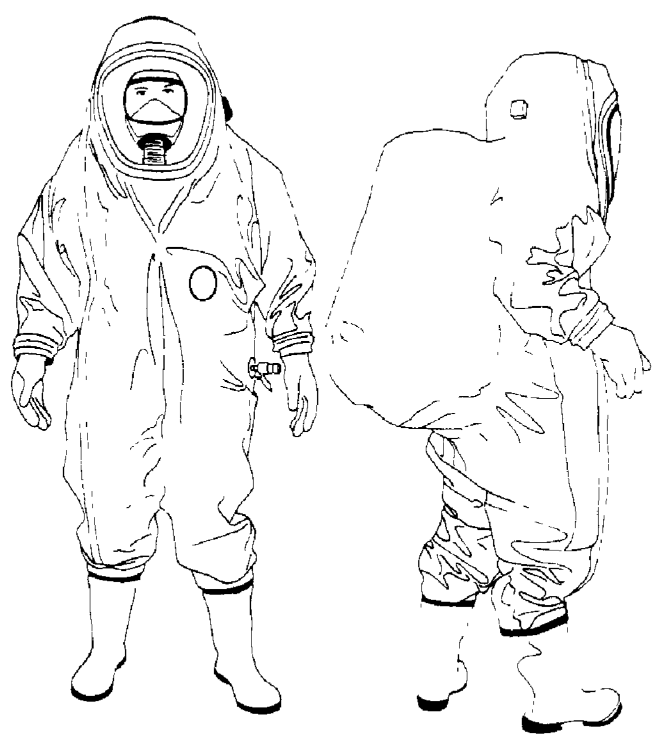


Exhibit I-8
Levels of Protection
(Continued)

Level B

Level C

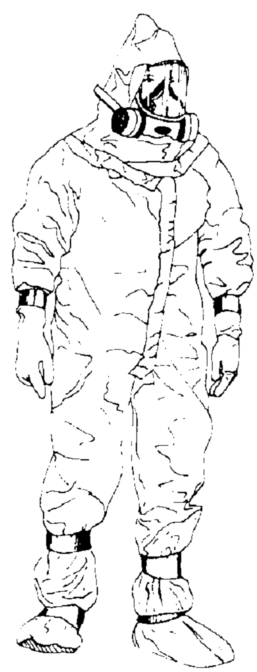
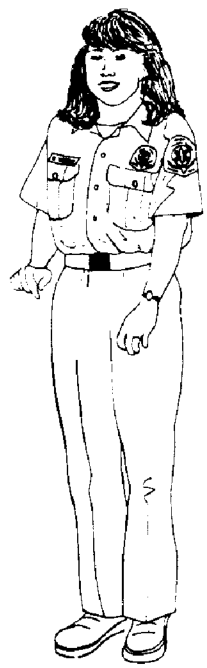


EXHIBIT I-8 (Continued)
Levels of Protection

Level D



Factors to be considered in selecting the proper level of protection include the routes of entry for the chemical, degree of contact, and the specific task assigned to the user. Activities can also be used to determine which level of protection should be chosen. The EPA and NIOSH recommend that initial entry into unknown environments and into a confined space that has not been chemically characterized be conducted in at least "Level B" 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 and must wear properly and be 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. 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 contact. Mucous membranes in the mouth, nose, throat, inner ear, and respiratory system are affected by one or more of the three primary 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, 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. However, there is not one single material that will afford protection against all substances. Thus, multilayered garments are often employed, which may reduce 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 worn equipment can expose and endanger the wearer. One factor to keep in mind during the selection process 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 injury.

The effectiveness of protective clothing 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. 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, that is, the molecular absorption by or passage through the protective material of a chemical substance.

Permeation is the process in 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 CPC. Most manufacturers of CPC provide charts on the breakthrough time, or the time it takes for the 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, button holes, 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-encapsulating 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 material. Selection of which kinds of CPC to use will depend on the specific chemical, and on the specific tasks to be performed.

Respiratory Protection

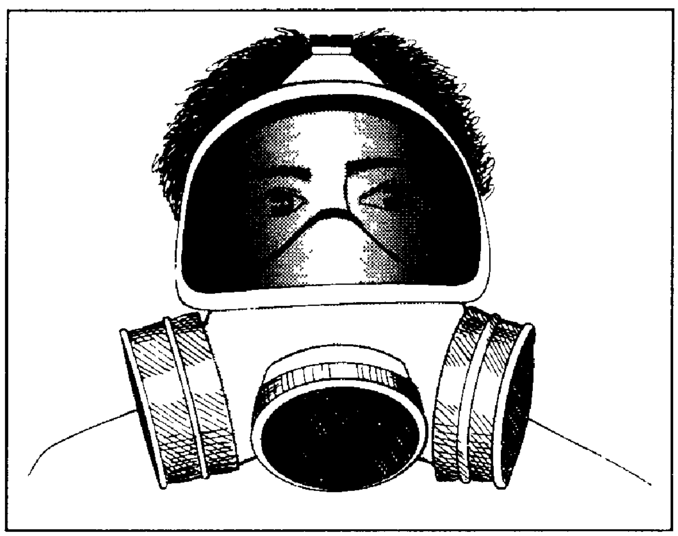
Substantial information is available for the correct selection, training, and use of respirators. The correct respirator must be selected for the specific hazard in question. Material safety data sheets (if available) often specify the type of respirator that will protect users from risks. The manufacturers suggest the types of hazards their respirators are capable of protecting against. There are two basic types of respirators: atmosphere-supplying and air-purifying. Atmosphere-supplying respirators include self-contained breathing apparatus (SCBA) and supplied-air respirators (SAR). The OSHA has requirements under 29 CFR 1910.134 which specify certain aspects of a respiratory protection standard, and these are mandatory legal minimums for a program to be operated. In addition, NIOSH has established comprehensive requirements for the certification of respiratory protection equipment.

Air-Purifying Respirators (APRs)

An air-purifying respirator depends on ambient air purified through a filtering element before inhalation. Three basic types of APRs are used by emergency personnel: chemical cartridges or canisters, disposables, and powered-air. The major advantage of the APR system is the increased mobility it affords the wearer. However, the respirator can only be used where there is sufficient oxygen (19.5%) since it depends on ambient air to function. In addition, the APR should not be used when substances with poor warning properties are known to be involved.

Exhibit I-9

A Chemical Cartridge Air-Purifying Respirator

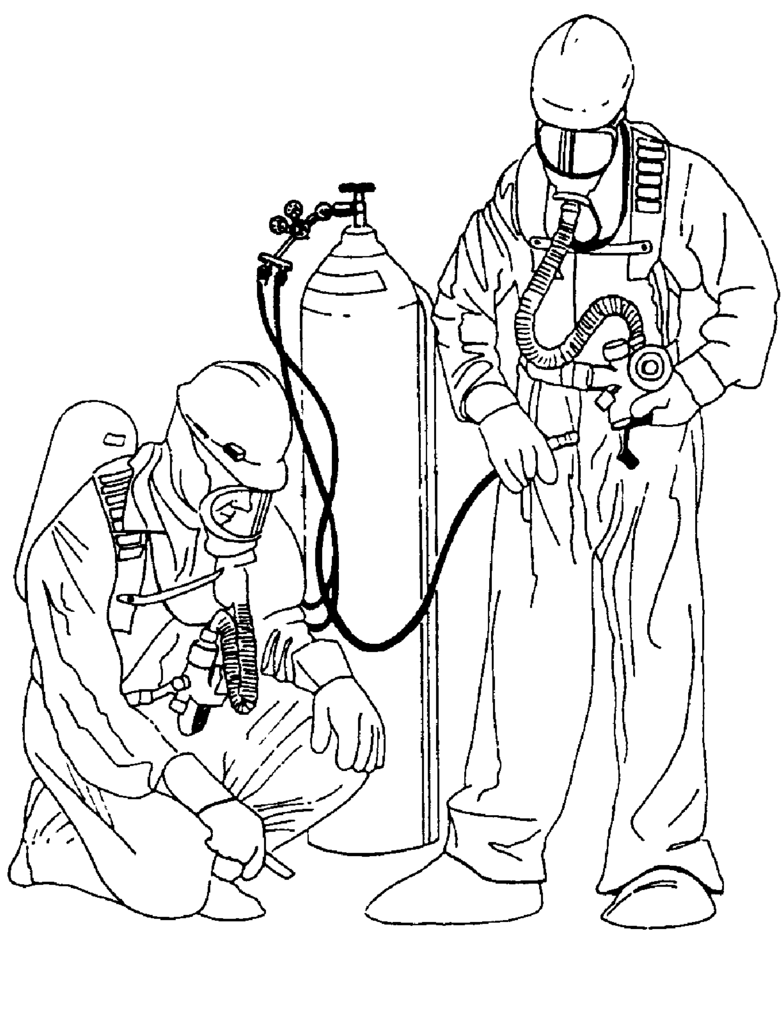


The most commonly used APR depends on cartridges (Exhibit I-9) or canisters to purify the air by chemical reaction, filtration, adsorption, or absorption. Cartridges and canisters are designed for specific materials at specific concentrations. To aid the user, manufacturers have color-coded the cartridges/

canisters to indicate the chemical or class of chemicals the device is effective against. 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. However, some are approved for use with other contaminants. These respirators are customarily 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 emergency response organizations.

Exhibit I-10
A Self-Contained Breathing Apparatus (Left)
and a Supplied-Air Respirator (Right)



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 I-10 illustrates an example of each.

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: closed-circuit, open-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.

The most common SCBA is the open-circuit, positive-pressure type. In this type, air is supplied to the wearer from a cylinder and supplied to 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 may force the contaminant out. There is a potential danger, when wearing a negative-pressure-type apparatus, 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. However, 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.

Personnel must be fit-tested for use of all respirators

A tiny space between the respirator and you could permit exposure to a hazard by allowing contaminated air in. Anyone attempting to wear any type of respirator should be trained and drilled in its proper use. Furthermore, equipment must be inspected and checked for serviceability on a routine basis.

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 the SAR allows an individual to work for a longer period. In addition, the SAR is less bulky than the SCBA. However, by necessity, a worker must retrace his steps to stay connected to the SAR, and therefore cannot leave the contaminated work area by a different exit.

Emergency Department Personnel Decontamination

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 stories are told of seemingly successful rescue, transport, and treatment of chemically contaminated individuals by unsuspecting emergency personnel who in the process contaminate themselves, the equipment, and the facilities they encounter along the way. 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; and
- Protects workers by reducing the contamination and resultant permeation of, or degradation to, their protective clothing and equipment

This section will only address the steps necessary for dealing with worker decontamination. Patient decontamination will be addressed in Section II. It should be stressed that in order 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, as presented in Exhibit I-11, need not be set up if only a boot-wash 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 or disposal of the worker's outer gear is recommended. Segregation and proper disposal of the outer gear in a polyethylene bag or steel drum is recommended. With extremely hazardous materials, it may be necessary to dispose of equipment as well.

Physical decontamination of protective clothing and equipment can be achieved in some cases by several different means. These all include the systematic removal of contaminants by washing, usually with soap and water, and then rinsing. In rare cases, the use of solvents may be necessary. There is a trend toward dry decontamination, which involves using disposable clothing (e.g., suits, boots, and gloves) and systematically removing these garments in a manner that precludes contact with the contaminant. The appropriate procedure will depend on the contaminant and its physical properties. A thorough work-up of the chemical involved and its properties or expert consultation is necessary to make these kinds of decisions.

Care must be taken to ensure that decontamination methods, because of their physical properties, do not introduce fresh hazards into the situation. Additionally, 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. Steps for dry decontamination (not using water) are outlined in Exhibit I-12.

Exhibit I-11
Nine-Step Personnel Decontamination Plan

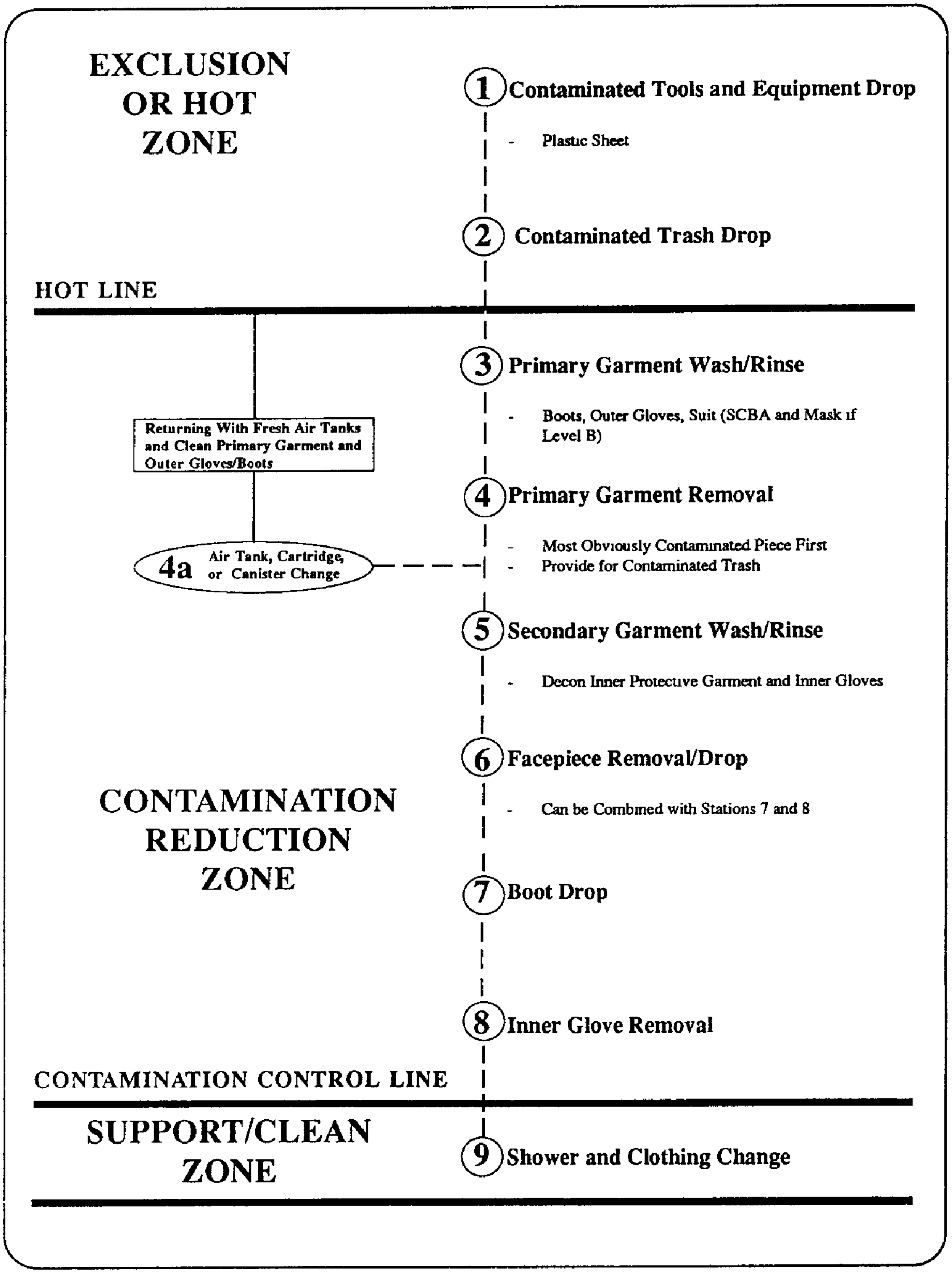
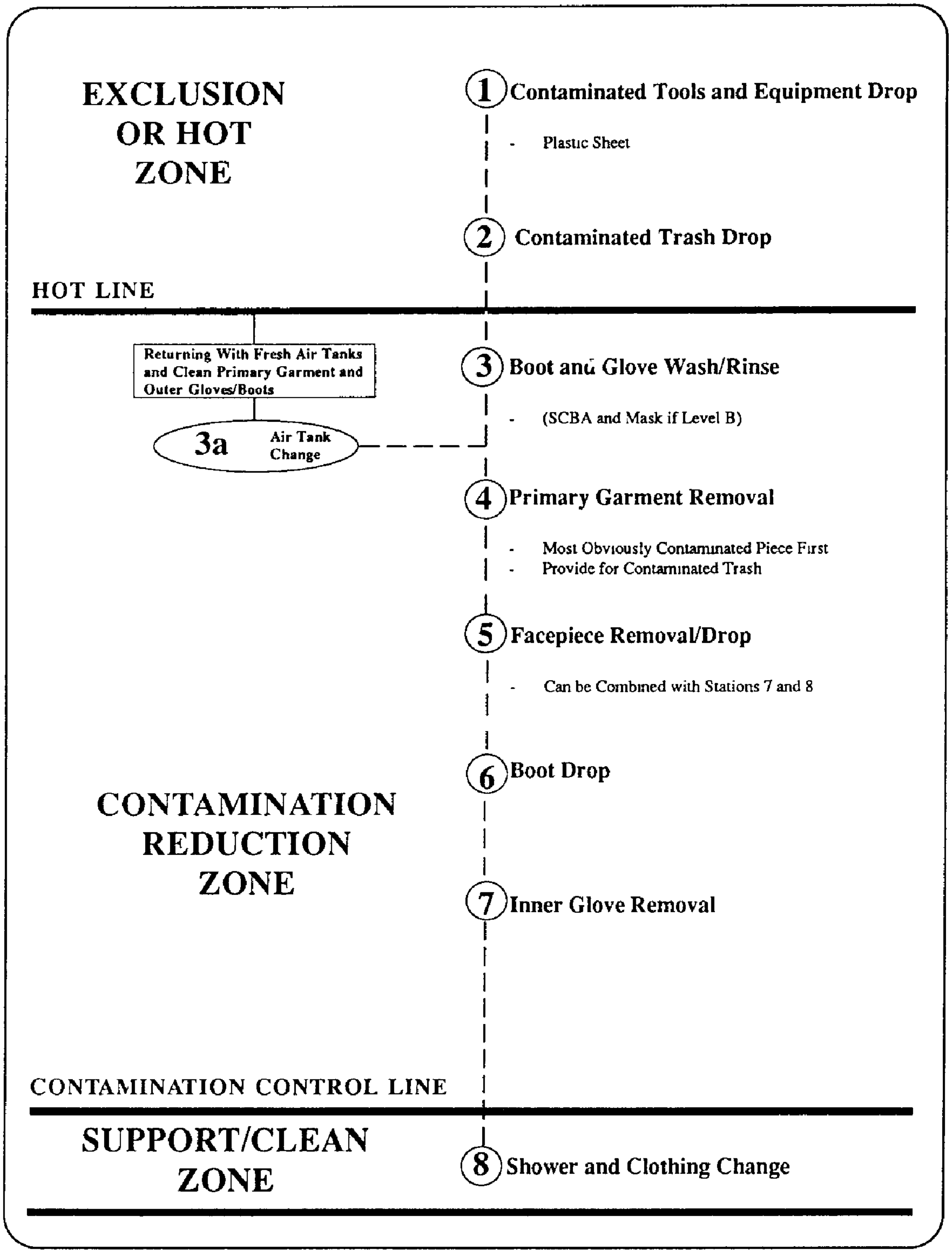


Exhibit I-12
Eight-Step Dry Decontamination Plan for Personnel



Decontamination of Personnel

Personnel should remove protective clothing in the following sequence.

1. **Remove tape securing gloves to suit.**
2. **Remove outer gloves turning them inside out as they are removed.**
3. **Remove suit turning it inside out and avoid shaking.**
4. **Remove plastic shoe cover from one foot and step over "clean line." Remove other shoe cover and put that foot over the line.**
5. **Remove mask. The last staff member removing his/her mask may want to wash all masks with soapy water before removing suit and gloves. Place masks in plastic bag and hand over the clean line, and place in second bag held by another member of the staff. Send for decontamination.**
6. **Remove inner gloves and discard in drum inside dirty area.**
7. **Close off dirty area until level of contamination is established and the area is properly cleaned.**
8. **Personnel should then move to a shower area, remove scrub suit and place it in a plastic bag.**
9. **Shower and redress in normal working attire.**

Note: Double bag clothing and label appropriately.

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 links the on-scene command post to support groups. Other networks that may have to be activated include one linking the hospital emergency room to EMTs and one dedicated for use by the teams in the Exclusion Zone. Often when an Incident Command System is activated, one person is assigned to manage communications.

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