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

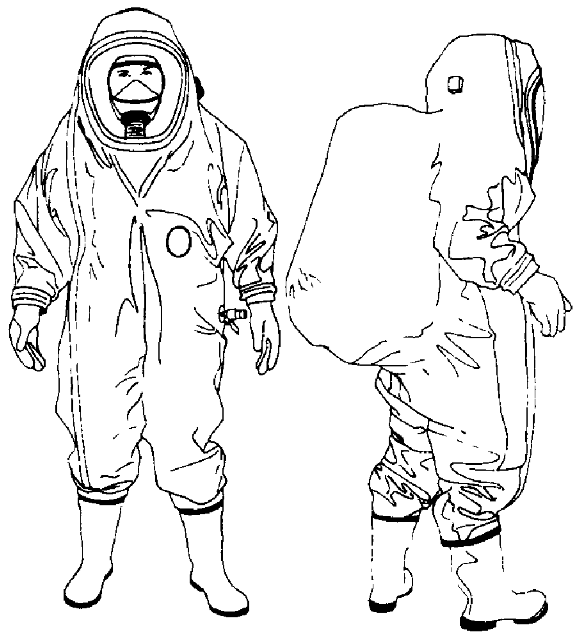
The Environmental Protection Agency (EPA) has assigned four levels of protection to assist in determining which combinations of respiratory protection and protective clothing should be employed:

- 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

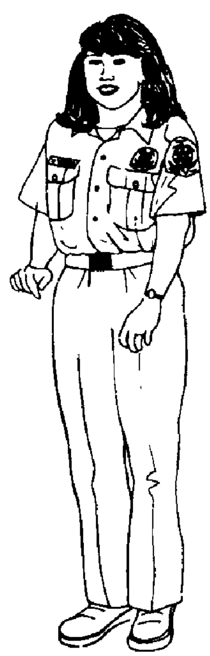


Level B

Exhibit I-8 (Continued)

Level C

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. EPA and NIOSH recommend that initial entry into unknown environments, unknown container sampling, and entry into a confined space that has not been chemically characterized warrants 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 be fitted properly and 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.

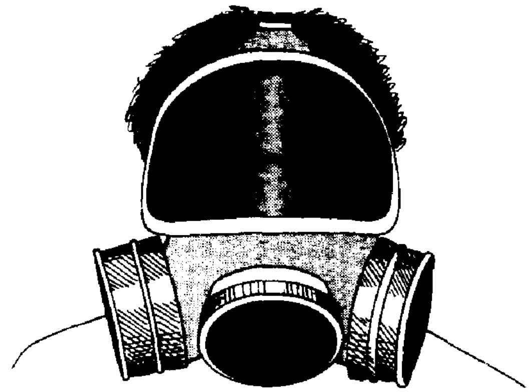
Respiratory Protection

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). 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 most emergency response organizations.

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 ambient air source. Exhibit I-10 illustrates an example of each.

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

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 contaminant 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.

Site Control

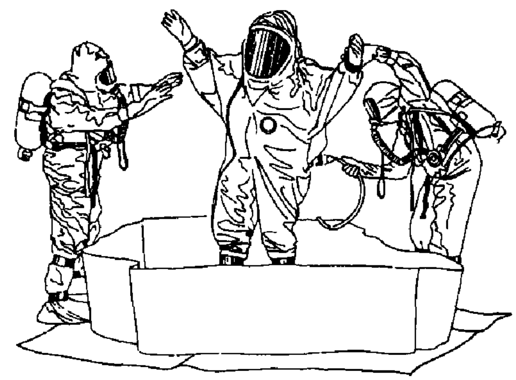
Hazardous materials incidents can and often do attract large numbers of people and equipment, complicating the imposition of adequate controls to minimize risks of human injury or death, property damage, and environmental degradation.

An Incident Command System (ICS) allows for the coordination and management of facilities, equipment, personnel, and communications during a hazardous materials incident. In order to keep the contaminants on-site, an Incident Commander (IC) is responsible for the control of the scene, which includes delineating work zones, establishing levels of protection, and implementing decontamination activities.

Rules to keep in mind to enhance control at the site of a chemical incident include the following: inactive individuals and equipment should be kept at a safe distance from the area of possible contamination; public access from all directions must be restricted as soon as possible; media access should be limited to the staging area, and any closer approach should involve escort by a designated Public Information Officer.

NIOSH/OSHA/USCG/EPA recommend dividing the incident into three zones, establishing access control points, and delineating a contamination reduction corridor. Exhibit I-11 presents a diagram of the recommended zones. The Exclusion Zone (hot zone) should encompass all known or suspected hazardous material contamination. The respective radius of the Contamination Reduction Zone (warm zone) is determined by the length of the decontamination corridor, containing all of the needed "decon" stations. The Support Zone (cold zone) should be "clean" — free of hazardous material contamination of all kinds, including discarded protective clothing and respiratory equipment. The command post and staging areas for necessary support equipment should be located upwind and uphill of the Exclusion Zone in the support area. 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 locations as possible.

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 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 incident 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 incident 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. It should be noted that 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-12, need not be set up if only a boot-wash station would suffice.

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

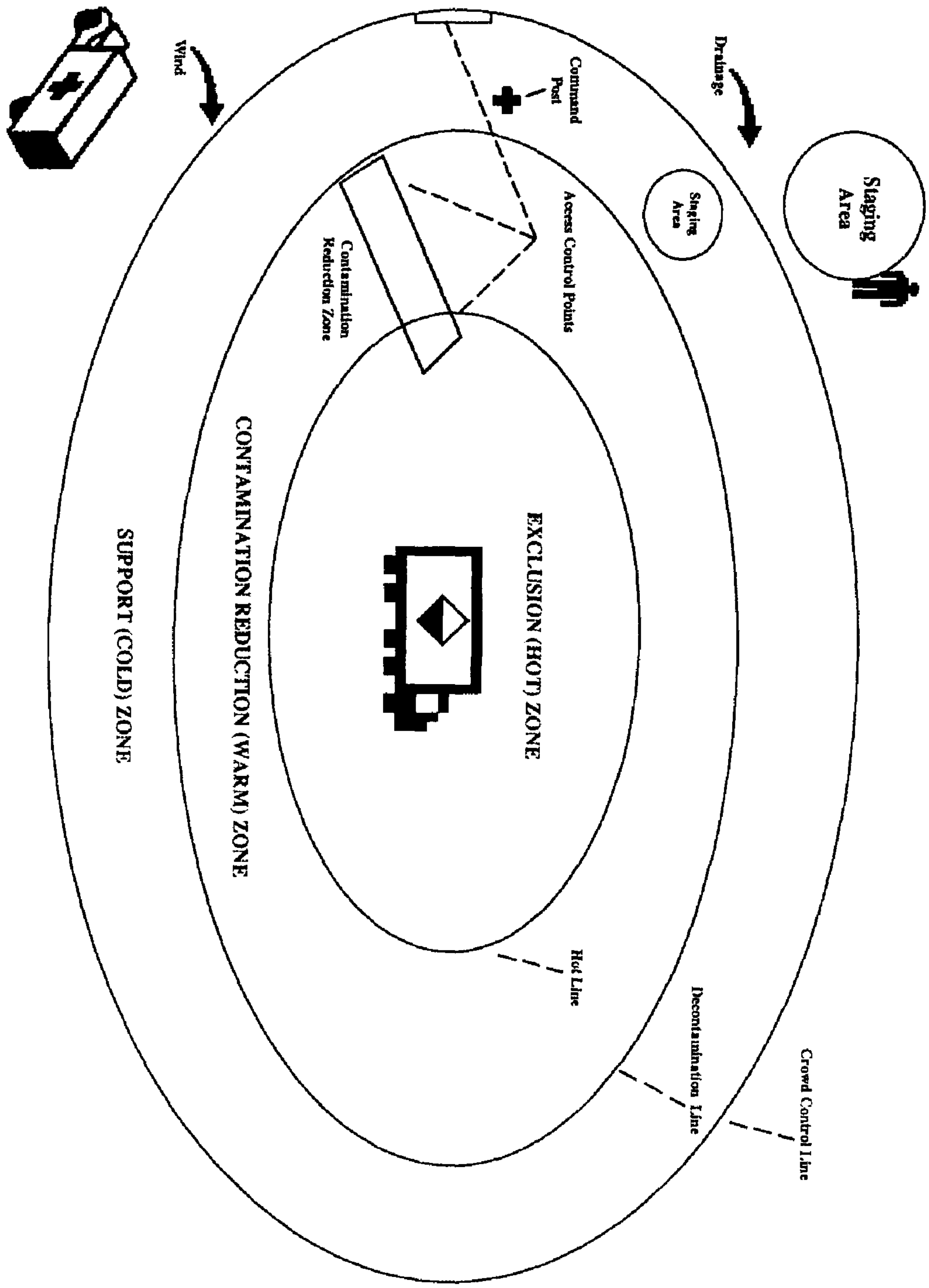
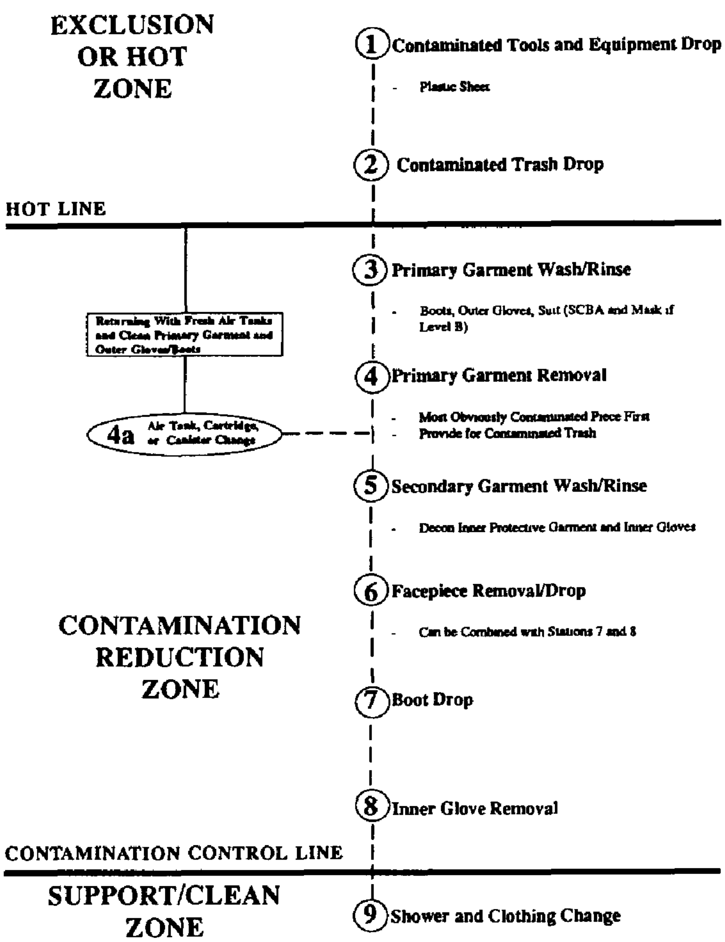


Exhibit I-12
Nine-Step Personnel Decontamination Plan

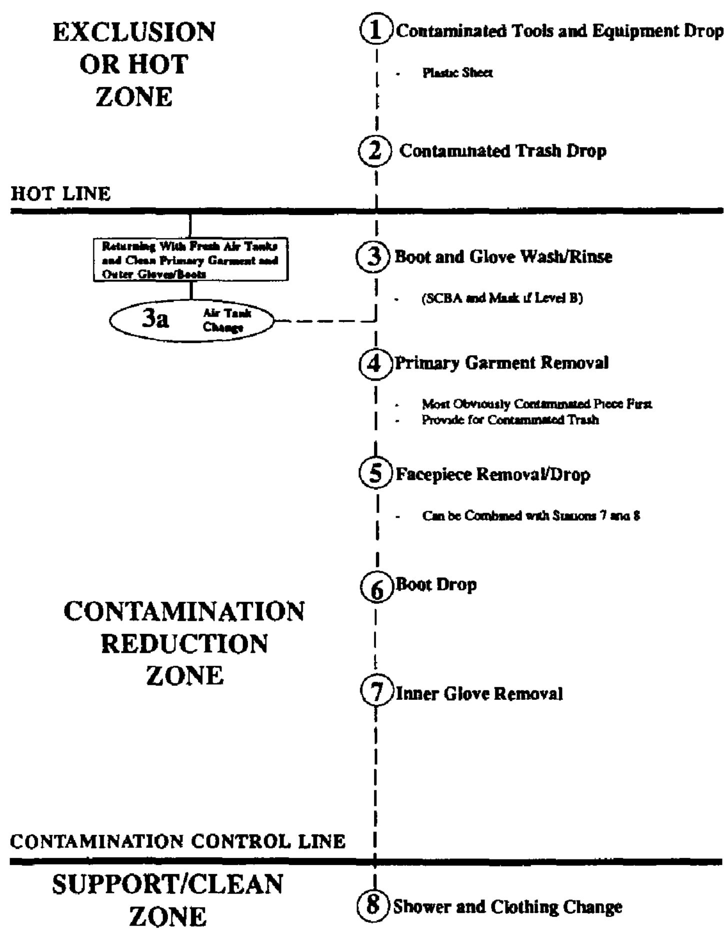


Avoiding contact is the easiest method of decontamination — that is, not to get the material on the worker or his protective equipment in the first place. However, if contamination is unavoidable, then proper decontamination or disposal of the worker's outer gear is recommended. Segregation and proper 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-13.

Exhibit I-13
Eight-Step Dry Decontamination Plan for Personnel



Decontamination of EMS Personnel

EMS 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 EMTs to the hospital emergency room and one dedicated for use by the teams in the Exclusion Zone. If a sufficient number of radios are not available for use in the exclusion zone, then line of sight must be maintained at all times for those personnel in the zone. Often when an Incident Command System is activated, one person is assigned to manage communications.

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