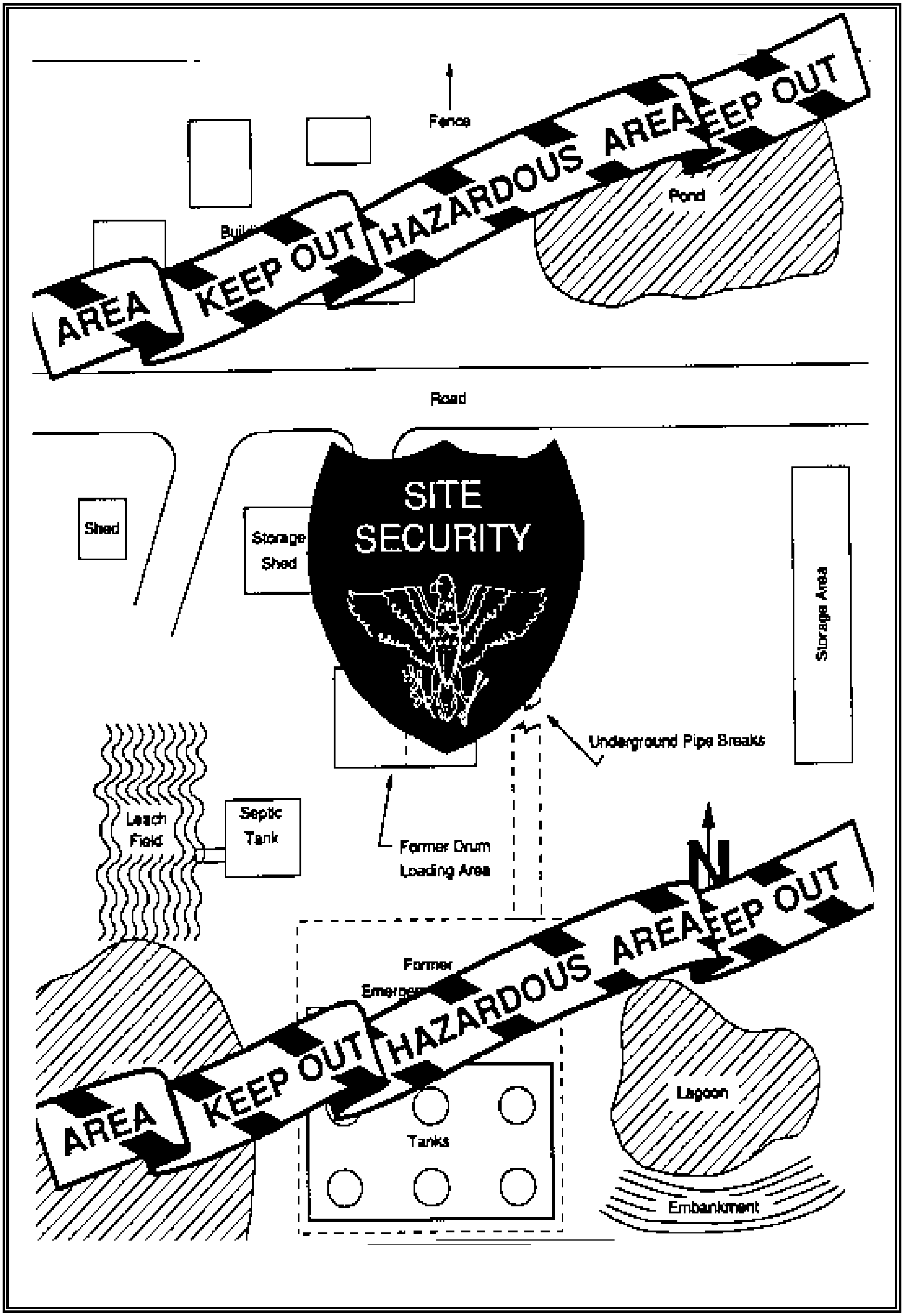
CHAPTER 4   SITE CONTROL



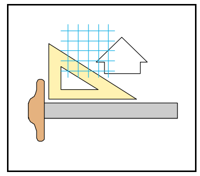
CHAPTER 4 SITE CONTROL

4.0 INTRODUCTION

As an essential element of the HASP, the site control program is used to control the activities and movement of people and equipment at hazardous waste sites in order to minimize the potential for worker exposure to hazardous substances. The provisions at 29 CFR §1910.120(d) require that an appropriate site control program be developed prior to the implementation of response operations. Although the degree of site control necessary for the protection of workers depends largely on site-specific characteristics (e.g., site size, nature of contamination, etc.), 29 CFR §1910.120(d)(3) identifies some essential elements of an effective site control program. These elements are highlighted in **Exhibit 4-1.**

The site control program should be established during the planning stages of a hazardous waste operation. It should be modified as new information becomes available, perhaps as a result of the initial site entry or subsequent site assessments. The appropriate sequence for implementing site control measures should be determined on a site-specific basis; however, it may be necessary to implement several measures concurrently. The remainder of this chapter provides more detail of each of the basic components of a site control program.

4.1 DEVELOPMENT OF THE SITE MAP



As part of the site control program, a map of the hazardous waste site should be developed. The site map represents a central source of information about the site, including the geographic layout and the hazards present at the site. The purpose of the site map is to assist site personnel in planning and organizing response activities. **Exhibit 4-2** presents an example of a site map.

The site map should be developed prior to the initial site entry using information obtained during the preliminary evaluation. The map should include the following information: prevailing wind direction, site drainage points, all natural and man-made topographic features including the location of buildings, containers, impoundments, pits, ponds, tanks, and any other site features. Site maps should be updated often during the course of site operations to reflect:

- New information, such as information gained after initial site entry or from subsequent sampling and analysis activities; or

EXHIBIT 4-1

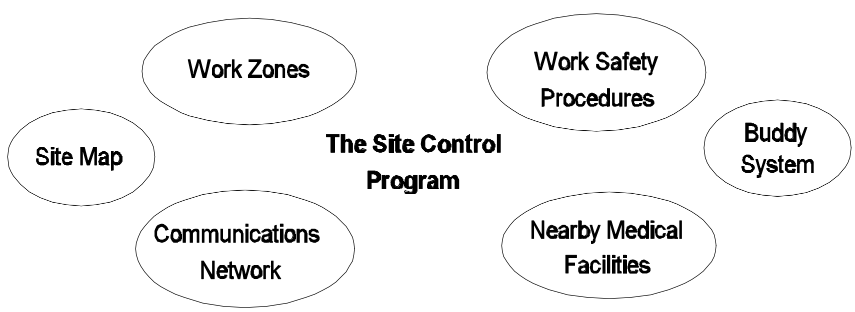
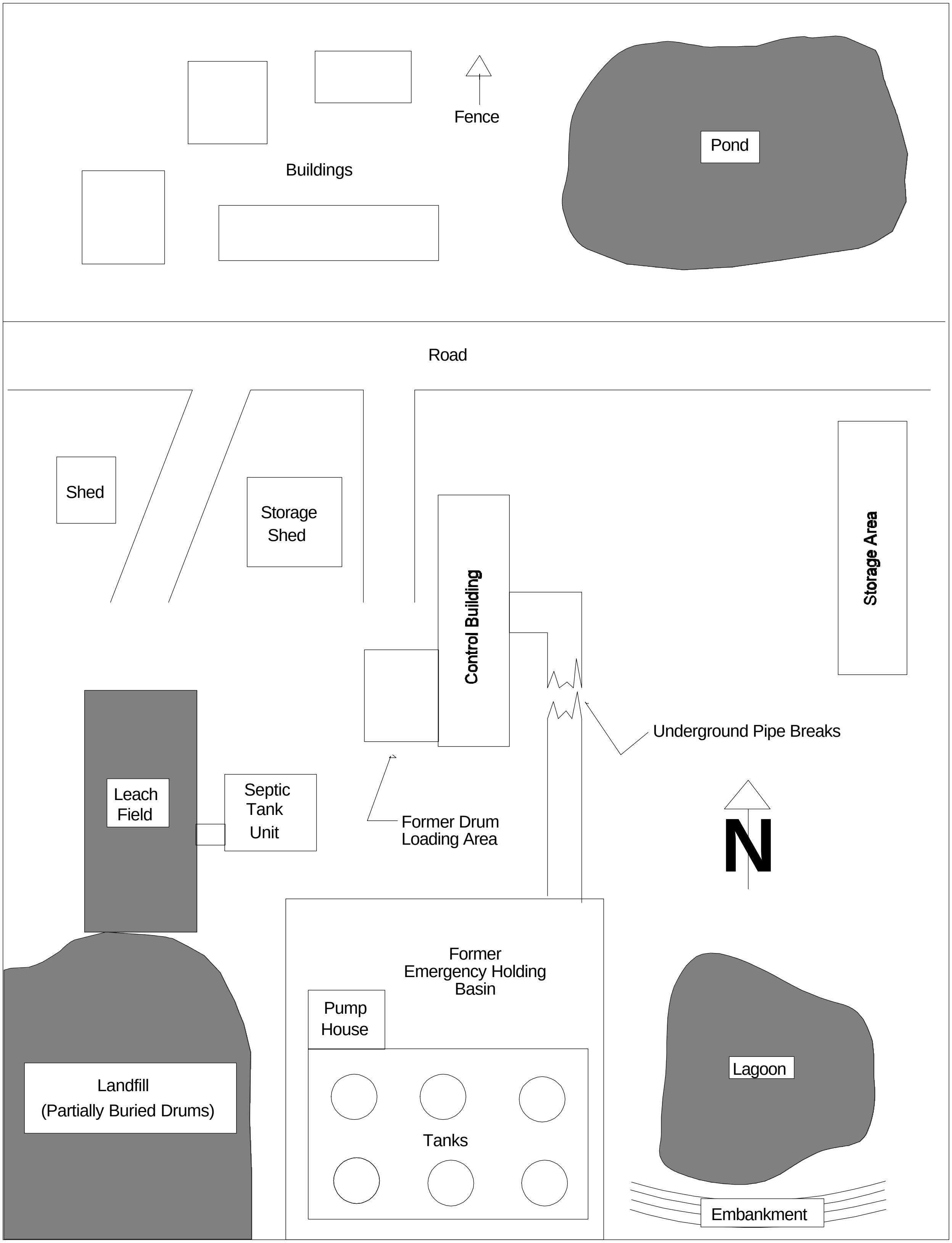


EXHIBIT 4-2

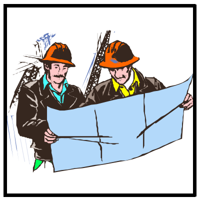


Sample Site Map

- Changes in site conditions, including changes resulting from accidents, ongoing site operations, hazards not previously identified, new materials introduced on-site, unauthorized entry or vandalism, or weather conditions.

As new information is added to the site map, use of overlays and other mapping techniques may reduce the potential cluttering of information.

4.2 ESTABLISHMENT OF WORK ZONES AT THE SITE



One of the basic elements of an effective site control program is the delineation of work zones at the site. This delineation specifies the type of operations that will occur in each zone, the degree of hazard at different locations within the site, and the areas at the site that should be avoided by unauthorized or unprotected employees. Specifically, the purpose of establishing work zones is to:

- Reduce the accidental spread of hazardous substances by workers or equipment from the contaminated areas to the clean areas;

- Confine work activities to the appropriate areas, thereby minimizing the likelihood of accidental exposure; and

- Facilitate the location and evacuation of personnel in case of an emergency.

When establishing the work zones at a site, information from on-site and off-site data collection efforts should be compiled in a format that facilitates a decision concerning the placement of work zones. The site map, as discussed above, can provide a useful format for compiling the relevant data. The locations of all potential hazards that were identified through the interview/records research, the perimeter reconnaissance, and the initial on-site survey should be plotted on the site map. The site map should also indicate both observed and suspected hazards, on- and off-site air and soil sampling results, and potential exposure pathways. It is important to remember that the absence of sampling results should not be considered evidence that an area is clean.

Although a site may be divided into as many zones as necessary to ensure minimal employee exposure to hazardous substances, the three most frequently identified zones are the Exclusion Zone (or "hot zone"), the Contamination Reduction Zone (CRZ), and the Support Zone (or "clean zone"). Movement of personnel and equipment between these zones should be minimized and restricted to specific access control points to prevent cross-contamination from contaminated areas to clean areas. **Exhibit 4-3** illustrates the three most commonly designated work zones. A description of each work zone, and the factors to be considered when establishing them, are provided below.

4.2.1 The Exclusion Zone

The Exclusion Zone is the area where contamination is either known or expected to occur and the greatest potential for exposure exists. The outer boundary of the Exclusion Zone, called the Hotline, separates the area of contamination from the rest of the site. The Hotline should initially be established by visually surveying the site and determining the areal extent of hazardous substances, discoloration, or any drainage, leachate, or spilled material present. Other factors to consider in establishing the Hotline include:

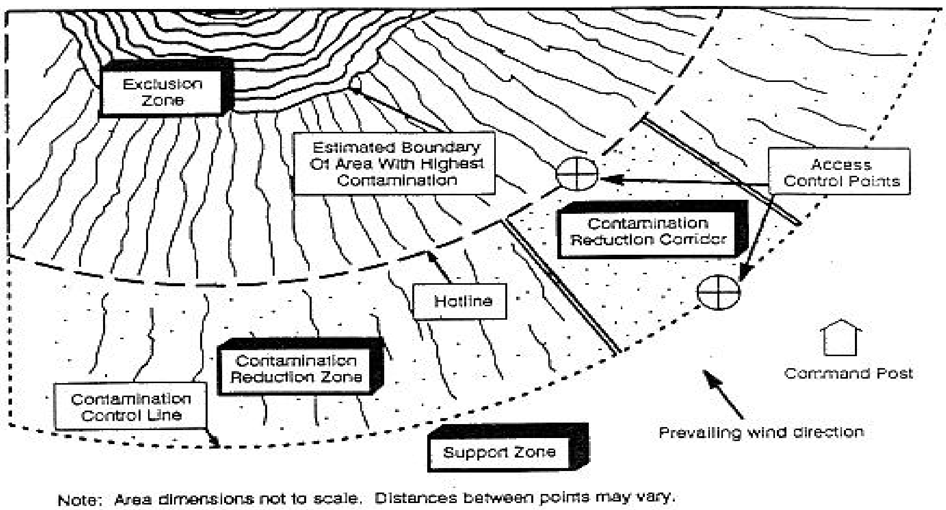
- Providing sufficient space to protect personnel outside the zone from potential fire or explosion;

- Allowing an adequate area in which to conduct site operations; and

- Reducing the potential for contaminant migration.

The Hotline should be physically secured (e.g., using chains, fences, or ropes) or clearly marked (e.g., using lines, placards, hazard tape, and/or signs). During subsequent site operations, the boundary may be modified and adjusted as more information becomes available. In addition, the Exclusion Zone may also be subdivided into different areas of contamination based on the known or expected type and degree of hazards or the incompatibility of waste streams. If the Exclusion Zone is subdivided in this manner, additional demarcations (e.g., "Hazards Present" or "Protection Required") may be necessary.
Access to and from the Exclusion Zone should be restricted to Access Control Points at the Hotline. Access Control Points are used to regulate the flow of personnel and equipment into and out of the contamination area and to verify that site control procedures are followed. Separate entrances and exits should be established to separate personnel and equipment movement into and out of the Exclusion Zone. If the Exclusion

EXHIBIT 4-3
Illustration of Typical Work Zones



Zone is subdivided, additional Access Control Points may be necessary to ensure minimal employee exposure.

All persons who enter the Exclusion Zone must wear the appropriate level of PPE for the degree and types of hazards present at the site. If the Exclusion Zone is subdivided, different levels of PPE may be appropriate (see **Chapter 5** for more information on PPE). Each subarea of the Exclusion Zone should be clearly marked to identify the hazards and the required level of PPE.

4.2.2 The Contamination Reduction Zone (CRZ)

As the transition area between the Exclusion Zone ("hot zone") and the Support Zone ("clean zone"), the CRZ is the area in which decontamination procedures take place. The purpose of the CRZ is to reduce the possibility that the Support Zone will become contaminated or affected by the site hazards. Because of both distance and decontamination procedures, the degree of contamination in the CRZ generally will decrease as one moves from the Hotline to the Support Zone.

Initially, the CRZ should be established outside the areas of contamination. Contamination Reduction Corridors, which are Access Control Points between the Exclusion Zone and the CRZ, should be established for both personnel and heavy equipment. These corridors should consist of an appropriate number of decontamination stations necessary to address the contaminants at a particular site (see **Chapter 9** for more information on decontamination procedures). In some cases, the scale of response operations may require more than two Contamination Reduction Corridors.

The Contamination Control Line marks the boundary between the CRZ and the Support Zone and separates the clean areas of the site from those areas used to decontaminate workers and equipment (i.e., partially contaminated areas). Access Control Points between the CRZ and the Support Zone must be established to ensure that workers entering the CRZ are wearing the proper PPE and that workers exiting the CRZ to the Support Zone remove all potentially contaminated PPE.

4.2.3 The Support Zone

The Support Zone is the uncontaminated area where workers are unlikely to be exposed to hazardous substances or dangerous conditions. The Support Zone is the appropriate location for the command post, medical station, equipment and supply center, field laboratory, and any other administrative or support functions that are necessary to keep site operations running efficiently. Because the Support Zone is free from contamination, personnel working within it may wear normal work clothes, and access to and from the area is not restricted to authorized site personnel. Any potentially contaminated clothing, equipment, and samples must remain outside of the Support Zone until decontaminated. However, all personnel located in the Support Zone must receive instruction in the proper evacuation procedures in case of a hazardous substance emergency.

Designation of the Support Zone should be based on all available site characterization data. One of the most important criteria for the selection of the Support Zone is that it must be located in a clean area. That is, the Support Zone should be in an area that is known to be free of elevated (i.e., higher than background) concentrations of hazardous substances. Monitoring should be conducted to confirm that the area considered for the Support Zone does not contain concentrations of hazardous substances that pose health risks (see **Chapter 6** for details on air monitoring procedures). When evaluating on-site concentrations of hazardous substances, it is important to consider the background concentrations of these substances in the area. In some cases, non-zero (low-level) background concentrations of hazardous substances may be encountered.

The size and position of the Support Zone may be directly affected by the size of the exclusion and contamination reduction zones. For example, the Support Zone may be constrained by the distances needed to prevent an explosion or fire from affecting personnel outside the Exclusion Zone, or the physical area required for activities within the Exclusion Zone. In addition, the Support Zone should be upwind and as far from the Exclusion Zone as practicable. Whenever possible, line-of-sight contact with all activities in the Exclusion Zone should be maintained, and accessibility to support services (e.g., power lines, access roads, telephones, shelter, and water) should be maximized. The expected duration of response operations may also affect the placement of work zones.

4.2.4 Ensuring Integrity of the Support Zone

It is conceivable that the Support Zone may inadvertently become contaminated after site remediation begins. For example, changes in wind speed and direction, temperature, and rainfall may result in exposures different from those experienced during the initial on-site survey. Therefore, the integrity of the Support Zone should be reconfirmed during response operations.

Several procedures can be used to ensure that the area chosen for the Support Zone remains clean during removal or remedial operations. First, the strict use of site controls will minimize the transfer of contamination to the Support Zone. In addition, periodic monitoring of the Support Zone will indicate whether changes in site activities or conditions have resulted in contamination. In the event that contamination has occurred, the boundaries of work zones should be reevaluated and, if appropriate, realigned. Procedures used to maintain work zone integrity are described below.

Use of Site Controls. The CRZ is designed to reduce the probability that the clean Support Zone will become contaminated or affected by other site hazards. The distance between the Exclusion and Support Zones provided by the CRZ, together with decontamination of workers and equipment, limits the physical transfer of hazardous substances into clean areas. The Contamination Control Line, which separates the Support Zone from areas of potential contamination, should include two Access Control Points, if feasible: one for personnel and one for equipment. Persons entering the CRZ should be required to wear PPE appropriate for the types and degree of hazards they may encounter when working in this area. To re-enter the Support Zone from the CRZ, workers should remove gross contamination, remove any protective clothing, leave equipment in the CRZ, and exit through the personnel Access Control Point.

Periodic Monitoring of Support Zone. A monitoring and sampling program for the Support Zone should be established to ensure that this area remains free from contamination. Monitoring should take place on a routine basis and whenever exposure is likely to have changed. The monitoring and sampling activities that may be conducted periodically to ensure that the Support Zone remains clean include:

- Air monitoring using direct-reading instruments.
- Collecting air samples for particulate, gas, and vapor analysis.
- Analysis of soil samples from areas of heavy traffic.

- Swipe tests in trailers and other areas used by personnel.

Increased concentrations of hazardous substances in air, soil, or other environmental media may indicate a breakdown in site control procedures or a change in on-site conditions. Site personnel should be constantly alert to changes in site conditions or the presence of any potentially dangerous situations. Certain site activities may increase the potential for exposure to hazardous substances and, therefore, may indicate a need for additional monitoring. These situations are listed in **Exhibit 4-4**.

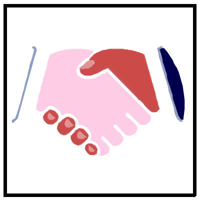
EXHIBIT 4-4
Additional Monitoring Requirements
(29 CFR §1910.120(h)(3))

As specified in 29 CFR §1910.120(h)(3), situations where additional monitoring may be appropriate include:

- When work begins on a different portion of the site;
- When contaminants other than those previously identified are being handled;
- When a different type of operation begins (e.g., drum opening as opposed to exploratory well drilling); and
- When employees are handling leaking drums or containers or working in areas with obvious liquid contamination (e.g., a spill or lagoon).

Additional Site Characterization Information. Additional information concerning locations of contaminated environmental media may become available during monitoring or in the later stages of site investigation and cleanup, particularly for remedial actions. For example, more detailed soil sampling will likely occur during the site inspection and remedial investigation. This additional information may indicate that areas initially thought to be clean are, in fact, contaminated. The location of the Support Zone should be re-evaluated whenever new site characterization studies are conducted.

4.3 ORGANIZATION OF WORKERS USING THE BUDDY SYSTEM



When carrying out activities in the Exclusion Zone, workers should use the buddy system to ensure that rapid assistance can be provided in the event of an emergency. The buddy system is an approach used to organize workers into workgroups so that each worker is designated to be observed by at least one other worker. During initial site entry, it may be appropriate to utilize a buddy system in which two workers are assigned to provide safety backup.

The site manager, who is responsible for enforcing the buddy system, should implement the system at the Access Control Point for personnel entering the Exclusion Zone. This location represents the most logical point to enforce the buddy system as the Site Manager is stationed in the CRZ and all personnel who enter the contaminated area are required to pass through the Access Control Point.

As part of the buddy system, workers should remain close together and maintain visual contact with each other to provide assistance in the event of an emergency. Should an emergency situation arise, workers should use the communication signals established and agreed upon prior to entering the contaminated area (see Section 4.4 below). In general, the responsibilities of workers utilizing the buddy system include:

- Providing his or her partner with assistance;
- Observing his or her partner for signs of chemical or heat exposure;
- Periodically checking the integrity of his or her partner's personal protective equipment; and
- Notifying the site manager or other site personnel if emergency assistance is needed.

Workers should not rely entirely on the buddy system to ensure that help will be provided in the event of an emergency. To augment this system, workers in contaminated areas should remain in line-of-sight or communication contact with the command post or site manager at all times.

4.4 ESTABLISHMENT OF A COMMUNICATION NETWORK AND PROCEDURES

Communication systems should be established at a site for both internal and external communication. Internal communication refers to communication between workers operating in the Exclusion Zone or CRZ, or to communication from the Command Post to these workers. Internal communication is generally used to:

- Alert team members to emergency situations;
- Convey safety information (e.g., air time remaining in SCBA, heat stress check, hazards detected);
- Communicate changes in the work to be accomplished; and
- Maintain site control.

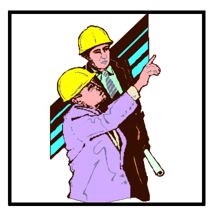
An internal communication system may be established using standard communication devices such as radio, noisemakers, or visual signals (**Exhibit 4-5** lists several common internal communications devices). All communication devices used in a potentially explosive atmosphere must be intrinsically safe (i.e., not capable of sparking) and should be checked daily to ensure that they are operating properly. Because verbal communication at a site can be difficult as a result of on-site background noise and the use of PPE (e.g., speech transmission through a respirator can be poor), pre-arranged commands and audio or visual cues should be developed prior to entering the Exclusion Zone. A secondary set of non-verbal signals should be established for use when communication devices fail or when emergency situations occur (see **Chapter 11** for procedures oncommunication during emergency situations).

Effective internal communication also requires the identification of individual workers so that commands can be addressed to the right worker. The worker's name should be marked on the suit and, for long-distance identification, color coding, numbers, or symbols can be added. Flags may be used to help locate personnel in areas where visibility is poor due to obstructions such as accumulated drums, equipment, or waste piles. External communication refers to communication between on-site and off-site personnel. An external communication system must be maintained in order to: (1) coordinate emergency response efforts with off-site responders; (2) report progress or problems to management; and (3) maintain telephone and radio. If telephone lines are not installed at a site, all team members should know the location of the nearest telephone to the site, and the correct change and necessary telephone numbers should be made readily available in the Support Zone. If a radio is used, its location should be clearly marked. Clear instructions for its use should be posted <u>with</u> the radio at all times.

EXHIBIT 4-5
Examples of
Internal Communication Devices

- **Radio**, including FM and Citizens Band;
- **Noisemakers**, including bells, compressed air horns, megaphones, sirens, or whistles; and
- **Visual Signals**, including flags, flare or smoke (only used in the Support Zone), hand signals, lights, signal boards, and whole body movements.

4.5 WORKER SAFETY PROCEDURES



As part of the site control plan, procedures must be established to ensure worker safety. Worker safety procedures include preparation of the sitefor response activities, engineering controls and safe work practices, and other standing orders to be followed at all times during site operations. Worker safety procedures should be prepared by certified safety professionals in advance of on-site response operations. These procedures should be made available to workers involved in site activities. <u>All</u> workers should be briefed frequently on their use.

4.5.1 Site Preparation

Prior to undertaking response activities, time and effort must be spent in preparing a site for clean-up activities to ensure that response operations go smoothly and that worker safety is ensured. <u>Because site preparation can be as hazardous as site cleanup, personnel should place high priority on safety measures at this stage of</u>

site operations. Prior to undertaking on-site response operations, the following site preparation activities should be performed:

- Construct roadways to provide a sound roadbed for heavy equipment and vehicles and arrange traffic patterns to provide ease of access and to ensure safe and efficient operations;
- Eliminate physical hazards from the site to the greatest extent possible, including:
  - ignition sources in flammable hazard areas;
  - exposed or ungrounded wiring, and low overhead wiring that may entangle equipment;
  - sharp or protruding edges (e.g., glass, nails, torn metal, etc.) that may puncture protective clothing and equipment or inflict puncture wounds;
  - debris, holes, loose steps or flooring, protruding objects, slippery surfaces, or unsecured railings, that can cause falls, slips, or trips, or obstruct visibility;
  - unsecured objects, such as bricks and gas cylinders near the edge of elevated surfaces such as catwalks, roof tops, and scaffolding, that may dislodge and fall on workers;
- Install skid-resistant strips and other anti-skid devices on slippery surfaces;
- Construct operation pads for mobile facilities and temporary structures, loading docks, processing and staging areas, and decontamination pads;
- Provide adequate illumination for work activities. Equip temporary lights with protective guards to prevent accidental contact; and
- Install wiring and electrical equipment in accordance with the National Fire Code.

4.5.2 Engineering Controls and Safe Work Practices

Engineering controls and safe work practices must be specified in the site control program to protect employees from exposure to hazardous substances and other safety and health hazards. Engineering controls and safe work practices should be implemented to reduce and maintain employee exposure levels at or below the permissible exposure levels (PELs) and published exposure levels for those hazardous substances at the site. Examples of engineering controls that may be used include pressurized cabins or control booths on equipment. Safe work practices include such activities as removing nonessential personnel from potential exposure during drum openings, wetting down dusty operations, and locating employees upwind of potential hazards. If, for whatever reason, it is not possible to maintain employee exposure to levels at or below PELs, technical assistance should be obtained before proceeding with site activities (e.g., consult EPA's Environmental Response Team (ERT) or OSHA).

Use of PPE should be a last resort to protect employees against possible exposure to hazardous substances. It should be used only when engineering controls and safe work practices are insufficient to adequately protect against exposure. The PPE used at a site must reflect the potential on-site hazards identified during the PE and site characterization (see **Chapter 5** for detailed information on using PPE).

4.5.3 Standing Orders

Standing orders should be established at a site to maintain a strong safety awareness and to enforce safe work practices. These orders typically are developed for the Exclusion Zone. If the hazards are sufficiently different, standing orders should be developed for the CRZ as well. Standing orders refer to those safety procedures that must always be followed when operating in contaminated areas. Examples of standing orders are provided in **Exhibit 4-6**.

To ensure that all workers are informed of the standing orders, they should be: (1) distributed to everyone who enters the site; and (2) posted conspicuously at the Command Post and at the entrance Access Control Points into the CRZ and/or the Exclusion Zone. In addition, the site manager should review the standing orders at each daily safety briefing and workers should be informed immediately of any new or revised procedures. addition to the procedures identified in the standing orders, a hazardous substance information form should be developed that lists the names and properties of all hazardous substances present at the site. This information should be conspicuously posted along with the standing orders. Finally, workers should be briefed on the site's hazardous substances when they first join the response team and when new substances are identified on-site.

4.6 IDENTIFICATION OF NEAREST MEDICAL ASSISTANCE

As part of the site control program, the site manager must post the identification and location of the nearest medical facilities where response personnel can receive assistance in the event of an emergency. Medical facilities typically include area hospitals, emergency clinics, on-call physicians, medical specialists, or emergency, ambulance, fire, and police services. Information to be maintained on the medical facilities should include the names, phone numbers, addresses, and procedures for contacting the facilities. Maps and directions to the medical facilities should also be provided. This information should be posted conspicuously throughout the site, as well as near telephones or other external communication devices.

Furthermore, all managers and individuals likely to become involved in medical response at the site should know the directions to the nearest medical facility. The staff at the designated facilities, as well as local Emergency Response personnel, should be aware of site activities and potential hazards prior to any site activity

EXHIBIT 4-6
Examples of Standing Orders

Report any signs of radioactivity, explosivity, or unusual conditions to your supervisor immediately

No Smoking, Eating, Drinking, or Open Flame in the Exclusion Zone or Contamination Reduction Zone

Check in at the entrance Access Control Point before entering the Exclusion Zone

Always wear SCBA while in the Exclusion Zone

Maintain close contact with your buddy in the Exclusion Zone

Check out at the exit Access Control Point before leaving the Exclusion Zone

FURTHER GUIDANCE: For more information on developing and implementing site controls, see:

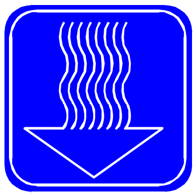
1. *Establishing Work Zones at Uncontrolled Hazardous Waste Sites* (U.S. EPA, 1991, Publication 9285.2-06FS).

2. *Standard Operating Guidelines for Establishing Work Zones* (U.S. EPA, 1985, Publication 9285.2-04A).

CHAPTER 5 PERSONAL PROTECTIVE EQUIPMENT

CHAPTER 5 PERSONAL PROTECTIVE EQUIPMENT

5.0 INTRODUCTION



Vapors, gases, and particulates from hazardous waste site activities place response personnel at risk. For this reason, site personnel must wear appropriate personal protective clothing and equipment (PPE) whenever they are near the site. The purpose of PPE is to shield or isolate individuals from the chemical, physical, and biologic hazards that may be encountered on-site. No single combination of protective clothing and equipment, however, is capable of protecting against all hazards; therefore, PPE should be used in conjunction with (**not in place of**) engineering controls and safe work practices. The effectiveness of the PPE program should be evaluated regularly.

The two basic objectives of any PPE program should be 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, §1910.120(g)(5) of the HAZWOPER standards requires a comprehensive PPE program as part of the site-specific HASP. **Exhibit 5-1** lists the main components of a PPE program. **Exhibit 5-2** lists the other regulations where OSHA has incorporated standards for PPE.

5.1 SELECTING THE LEVEL OF PPE

As required by HAZWOPER, PPE must protect employees from the specific hazards they are likely to encounter on-site. Selection of the appropriate PPE is a complex process that should take into consideration a variety of factors. Key factors might include: (1) identification of the hazards or suspected hazards; (2) potential exposure routes (e.g., inhalation, skin absorption, etc.); and (3) the performance of the PPE materials and seams in providing a barrier to these hazards.

The amount of protection offered by a particular type of PPE is material/hazard-specific. That is, certain types of PPE will protect well against some hazards and poorly, or not at all, against others. Other factors in the selection process include matching the PPE to the employee's work requirements and task-specific conditions. The durability of the PPE material, as well as its performance in extreme heat or cold, must also be considered.

Several guidelines and data bases exist that provide information on protective clothing (e.g., Guidelines for the Selection of Chemical Protective Clothing, and the Chemical Protective Clothing Performance Index). The National Fire Protection Association (NFPA) also issues information and standards (e.g., NFPA 1991: *Stand on Vapor-Protection Suits for Hazardous Chemical Emergencies*). These standards and guides provide data on chemical resistance, design and construction application, reuse and costs. The NFPA standards also provide information on flammability resistance.

The more that is known about the hazards at the site, the easier it becomes to select PPE. As more information about the hazards and conditions at the site becomes available, the site manager can make decisions to upgrade or downgrade the level of PPE protection to match the tasks at hand and the site hazards. One method of selecting the appropriate level of PPE is to use a numerical criterion -- the total atmospheric vapor/gas concentration. **Exhibit 5-3** outlines the level of PPE required for different ranges of vapor/gas concentrations. (**Chapter 6** provides more detailed information on using action levels to select appropriate levels of protection.)

The following sections present additional guidelines for selecting the appropriate level of PPE. **Exhibit 5-4** provides examples of typical protective clothing, and **Exhibit 5-5** provides sample protective ensembles for each of the four levels of protection (i.e., levels A-D).

5.1.1 Level A

Level A protection is required when the greatest potential for exposure to hazards exists, and when the greatest level of skin, respiratory, and eye protection is required. The following are examples of appropriate Level A equipment: positive pressure, full face-piece self-contained breathing apparatus (SCBA) or positive pressure supplied air respirator with escape SCBA; totally-encapsulating chemical-protective suit; inner and/or outer chemical-resistant gloves; and disposable protective suit, gloves, and boots.

Meeting any of the following criteria warrants use of Level A protection:

- Hazardous substances have been identified and require the highest level of protection

EXHIBIT 5-2
Additional Regulations Incorporated by OSHA for Personal Protective Equipment

29 CFR 1910.120: Hazardous Waste Operations and Emergency Response

29 CFR 1910.132: 41 CFR 50-204.7 (General Requirements for Personal Protective Equipment

29 CFR 1910.133(a): ANSI* Z87.1-1968 (Eye and Face Protection)

29 CFR 1910.134: ANSI Z88.2-1969 (Standard Practice for Respiratory Protection)

29 CFR 1910.135: ANSI Z89.1-1969 (Safety Requirements for Industrial Head Protection)

10 CFR 1910.136: ANSI Z41.1-1967 (Men's Safety Toe Footwear)

29 CFR 1926.100: Head Protection
29 CFR 1926.101: Hearing Protection
29 CFR 1926.102: Eyes and Face Protection
29 CFR 1926.103: Respiratory Protection

* American National Standards Institute

for skin, eyes, and the respiratory system;

- The atmosphere contains less than 19.5 percent oxygen;
- Site operations involve a high potential for splash, immersion, or exposure to unexpected materials that are harmful to the skin;
- Operations are being conducted in confined, poorly ventilated areas, and the absence of hazardous substances has not yet been determined; or
- Direct-reading instruments indicate high levels of unidentified vapors or gases in the air.

It may be necessary to base the decision to use Level A protection on indirect evidence. Other conditions that may indicate the need for Level A protection include:

- Confined spaces;
- Suspected or known highly toxic substances, especially when field equipment is not available to test concentrations;
- Visible indicators such as leaking containers or smoking chemical fires; and
- Potentially dangerous tasks, such as initial site entry.

5.1.2 Level B

Level B protection is required under circumstances requiring the highest level of respiratory protection, with a lesser level of skin protection. Potential Level B equipment includes: positive pressure, full face-piece SCBA or positive pressure supplied air respirator with escape SCBA; inner and/or outer chemical-resistant gloves; face shield; hooded chemical resistant clothing; coveralls; and outer chemical-resistant boots.

Meeting any of the following criteria warrants use of Level B protection:

- The type and atmospheric concentration of substances have been identified and require a high level of respiratory protection, but less skin protection than Level A;
- The atmosphere contains less than 19.5 percent oxygen; or
- The presence of incompletely identified vapors and gases is indicated but they are not suspected of being harmful to the skin.

EXHIBIT 5-3
Suggested Action Levels for PPE*

Level of Protection	Action Level (in ppm above background)
A	500 to 1,000 ppm
B	5 to 500 ppm
C	Background to 5 ppm
D	N/A

* Note that action levels for PPE based on vapor concentration are **only** for situations where the identity of the vapor or gas constituents are unknown. They do not address IDLH environments. Refer to Section 6.9 for more information.

EXHIBIT 5-4
Typical Protective Clothing

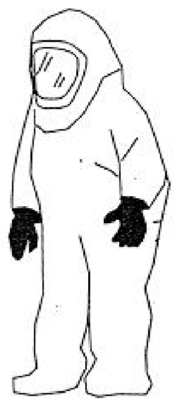
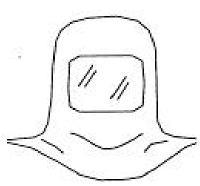
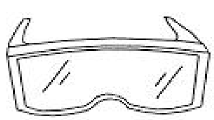
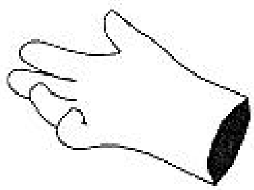
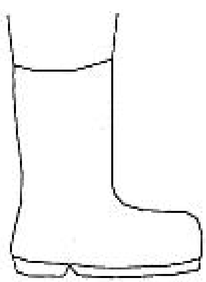
Body Part Protected	Type of Clothing	Type of Protection and Precautions
FULL BODY 	Fully-encapsulating suit (one-piece garment. Boots and gloves may be integral, attached and replaceable, or separate).	Protects against gases, dusts, vapors, and splashes. Does not allow body heat to escape. May contribute to heat stress in wearer.
	Non-encapsulating suit (jacket, hood, pants, or bib overalls, and one-piece coverall).	Protects against splashes, dust, and other materials but not against gases and vapors. Does not protect parts of head and neck. Do not use where gas-tight or pervasive splashing protection is required.
	Aprons, leggings, and sleeve protectors (may be integral or separate). Often worn over non-encapsulating suit.	Provides additional splash protection of chest, forearms, and legs. Useful for sampling, labeling, and analysis operations.
	Radiation-contamination protective suit.	Protects against alpha and beta particles. Does NOT protect against gamma radiation. Designed to prevent skin contamination.
	Flame/fire retardant coveralls (normally worn as an undergarment).	Provides protection from flash fires. May exacerbate heat stress.
HEAD 	Safety helmet (hard hat, made of hard plastic or rubber). May include a helmet liner to insulate against cold.	Protects the head from blows, must meet OSHA requirements at 29 CFR §1910.135.
	Hood (commonly worn over a helmet).	Protects against chemical splashes, particulates, and rain.
	Protective hair covering.	Protects against chemical contamination of hair, prevents hair from tangling in equipment, and keeps hair away from respiratory devices.
EYES & FACE 	Face shield (full-face coverage, eight-inch minimum) or splash hood.	Protects against chemical splashes, but does not protect adequately against projectiles. Provides limited eye protection.
	Safety glasses.	Protects eyes against large particles and projectiles.
	Goggles.	Depending on their construction, can protect against vaporized chemicals, splashes, large particles, and projectiles.

EXHIBIT 5-4
Typical Protective Clothing (cont'd)

Body Part Protected	Type of Clothing	Type of Protection and Precautions
EARS 	Ear plugs and muffs.	Protects against physiological damage from prolonged loud noise. Use of ear plugs should be reviewed by a health and safety officer because chemical contaminants could be introduced into the ear.
	Headphones (radio headset with throat microphone).	Provides some hearing protection while allowing communication.
HANDS & ARMS 	Gloves and sleeves (may be integral, attached, or separate from other protective clothing).	Protects hands and arms from chemical contact. Wearer should tape-seal gloves to sleeves to provide additional protection and to prevent liquids from entering sleeves. Disposable gloves should be used when possible to reduce decontamination needs.
FEET 	Chemical-resistant safety boots.	Protects feet from contact with chemicals.
	Steel-shank or steel-toe safety boots.	Protects feet from compression, crushing, or puncture by falling, moving, or sharp objects. Should provide good traction.
	Non-conductive or spark-resistant safety boots.	Protects the wearer against electrical hazards and prevents ignition of combustible gases or vapors.
	Disposable shoe or boot covers (slips over regular foot covering).	Protects safety boots from contamination and protects feet from contact with chemicals. Use of disposable covers reduces decontamination needs.

LEVEL OF PROTECTION A			
Equipment	**Protection Provided**	**Should Be Used When:**	**Limiting Criteria**
RECOMMENDED: • Pressure-demand, full-facepiece SCBA or pressure-demand supplied-air respirator with escape SCBA. • Fully-encapsulating, chemical-resistant suit. • Inner chemical-resistant gloves. • Chemical-resistant safety boots/shoes. • Two-way radio communications. **OPTIONAL:** Hard hat. Coveralls.Cooling unit. Long cotton underwear. Disposable gloves and boot covers.	The highest available level of respiratory, skin, and eye protection.	1. The chemical substance has been identified and requires the highest level of protection for skin, eyes, and the respiratory system based on either: - measured (or potential for) high concentration of atmospheric vapors, gases, or particulates; or - site operations and work functions involving a high potential for splash, immersion, or exposure to unexpected vapors, gases, or particulates of materials that are harmful to skin or capable of being absorbed through the intact skin. 2. Substances with a high degree of hazard to the skin are known or suspected to be present, and skin contact is possible. 3. Operations must be conducted in confined, poorly ventilated areas until the absence of conditions requiring Level A protection is determined.	Fully encap-sulating suit material must be compatible with the substances involved.

LEVEL OF PROTECTION B			
Equipment	**Protection Provided**	**Should Be Used When**	**Limiting Criteria**
RECOMMENDED: • Pressure-demand, full-facepiece SCBA or pressure-demand supplied-air respirator with escape SCBA. • Chemical-resistant clothing (overalls and long-sleeved jacket; hooded, one- or two-piece chemical splash suit; disposable chemical-resistant one-piece suit). • Inner and outer chemical-resistant gloves. • Chemical-resistant safety boots/shoes. • Hard hat. • Two-way radio communications. **OPTIONAL:** Coveralls. Face shield. Disposable boot covers. Long cotton underwear.	The same level of respiratory protection but less skin protection than Level A. It is the minimum level recommended for initial site entries until the hazards have been further identified.	1. The type and atmospheric concentration of substances have been identified and require a high level of respiratory protection, but less skin protection. This involves atmospheres: - with IDLH concentrations of specific substances that do not represent a skin hazard; or - that do not meet the criteria for use of air-purifying respirators. 2. Atmosphere contains less than 19.5 percent oxygen. 3. Presence of incompletely identified vapors or gases is indicated by direct-reading organic vapor detection instrument, but vapors and gases are not suspected of containing high levels of chemicals harmful to skin or capable of being absorbed through the intact skin.	Use only when the vapor or gases present are not suspected of containing high concentrations of chemicals that are harmful to skin or capable of being absorbed through the intact skin.

EXHIBIT 5-5
Sample Protective Ensembles (cont'd)

LEVEL OF PROTECTION C			
Equipment	**Protection Provided**	**Should Be Used When:**	**Limiting Criteria**
RECOMMENDED: • Full-facepiece, air-purifying, canister-equipped respirator. • Chemical-resistant clothing (overalls and long-sleeved jacket; hooded, one- or two-piece chemical splash suit; disposable chemical-resistant one-piece suit). • Inner and outer chemical-resistant gloves. • Chemical-resistant safety boots/shoes. • Hard hat. • Two-way radio communications. **OPTIONAL:** Coveralls. Disposable boot covers. Face shield. Long cotton underwear. Use of escape mask during initial entry is optional only after characterization (29 CFR 1910.120(c)(5)(ii)).	The same level of skin protection as Level B, but a lower level of respiratory protection.	1. The atmospheric contaminants, liquid splashes, or other direct contact will not adversely affect any exposed skin. 2. The types of air contaminants have been identified, concentrations measured, and a canister is available that can remove the contaminant. 3. All criteria for the use of air-purifying respirators are met.	Atmospheric concentration of chemicals must not exceed IDLH levels. The atmosphere must contain at least 19.5 percent oxygen.

LEVEL OF PROTECTION D			
Equipment	**Protection Provided**	**Should Be Used When**	**Limiting Criteria**
RECOMMENDED: • Coveralls. • Safety boots/shoes. • Safety glasses or chemical splash goggles. • Hard hat. **OPTIONAL:** Gloves. Escape mask. Face shield.	No respiratory protection. Minimal skin protection.	1. The atmosphere contains no known hazard. 2. Work functions preclude splashes, immersion, or the potential for unexpected inhalation of or contact with hazardous levels of any chemicals.	This level should not be worn in the Exclusion Zone. The atmosphere must contain at least 19.5 percent oxygen.

The use of Level B protection does not afford as great a level of protection to the skin and eyes as Level A, but it does provide a high level of respiratory protection. At most abandoned, outdoor hazardous waste sites, ambient atmospheric vapor or gas levels have not approached sufficiently high concentrations to warrant Level A protection. Level B protection is often adequate.

5.1.3 Level C

Level C protection is required when the concentration and type of airborne substances is known, and the criteria for using air purifying respirators is met. Typical Level C equipment includes: full-face air-purifying respirators, inner and outer chemical-resistant gloves, hard hat, escape mask, and disposable chemical-resistant, outer boots.

Meeting any of the following criteria warrants use of Level C protection:

- The atmospheric contaminants, liquid splashes or other direct contact will not adversely affect or be absorbed by the skin;

- The types of air contaminants have been identified, concentrations do not exceed IDLH levels, and an air-purifying respirator is available that can remove the contaminants; and

- Oxygen concentrations are not less than 19.5 percent by volume, and job functions do not require SCBA.

Level C protection is distinguished from Level B by the equipment used to protect the respiratory system, assuming the same type of chemical-resistant clothing is used. The main selection criterion for Level C is that atmospheric concentrations and other selection criteria permit wearing an air-purifying respirator.

5.1.4 Level D

Level D is the minimum protection required. Appropriate Level D protective equipment may include: gloves, coveralls, safety glasses, face shield, and chemical-resistant steel-toe boots or shoes. Level D protection is primarily a work uniform. This protection is sufficient under the following conditions:

- No contaminants are present; or

- Work operations preclude splashes, immersion, or the potential for unexpected inhalation of or contact with hazardous levels of any chemicals.

While these are guidelines for typical equipment to be used in certain circumstances, other combinations of protective equipment may be more appropriate, depending upon specific site characteristics. As an aid to selecting appropriate protective wear, it is recommended that chemical protective suits meet the standards developed by the National Fire Protection Association (NFPA).

5.2 ELEMENTS OF THE PPE PROGRAM

The comprehensive PPE program must address a number of specific factors in addition to selection of the appropriate level of protection. These factors are discussed below. Site managers should also refer to the *Standard Operating Procedures for Site Entry* for additional technical guidance in the use and selection of PPE.

5.2.1 Personal Use Factors and Equipment Limitations

Certain personal features of workers may jeopardize safety during equipment use. Prohibitive or precautionary measures should be taken as necessary for the following personal features:

<u>Facial hair and long hair</u> that passes between the face and the sealing surface of the respirator should be prohibited because it interferes with respirator fit and wearer vision, allowing excessive contaminant penetration. Long hair must be effectively contained within protective hair coverings.

<u>Eyeglasses</u> with conventional temple pieces will interfere with the respirator-to-face seal of a full face-piece. A spectacle kit should be installed in the face masks of workers requiring vision correction, providing a gas-tight seal. Contact lenses may trap contaminants and/or particulate between the lens and the eye, causing irritation. Wearing contact lenses with a respirator in a contaminated atmosphere is prohibited (29 CFR §1910.134(e)(5)(iii)).

<u>Gum and tobacco chewing</u> should be prohibited during respirator use because they may cause ingestion of contaminants and may compromise the respirator fit.

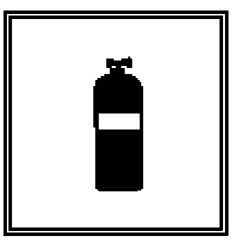
It is especially important to understand all aspects of the clothing operation and the limitations of fully-encapsulating ensembles, as misuse could result in suffocation. During equipment use, workers should be encouraged to report any perceived problems or difficulties to their supervisor(s). These malfunctions may include, but are not limited to:

- Degradation of the protective ensemble.
- Perception of odors.
- Skin irritation.
- Unusual residues on PPE.
- Discomfort.
- Resistance to breathing.
- Fatigue due to respirator use.
- Interference with vision or communication.
- Restriction of movement.
- Personal responses such as rapid pulse, nausea, and chest pain.

If a supplied-air respirator is being used, all hazards that might endanger the integrity of the air line should be removed from the working area prior to use. During use, other workers and vehicles should be excluded from the area.

5.2.2 Work Mission Duration

In selecting PPE, it is important to consider the anticipated duration of the work mission. Several factors may limit the mission length, including: air supply, equipment effectiveness, temperature, and coolant supply.

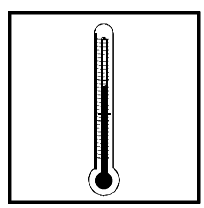


Air Supply Consumption. The duration of the air supply must be considered before planning any SCBA-assisted work activity. The anticipated oper-ating time of a SCBA is clearly indicated on the breathing apparatus. This designated operating time is based on a moderate work rate used in the NIOSH/ MSHA certification test. In actual operation, however, several factors can reduce the rated operating time. The following variables should be considered to adjust work actions and operating time accordingly:

- Work rate. The actual in-use duration of SCBAs may be reduced by one-third to one-half during strenuous work (e.g., drum handling, major lifting, or any task requiring repetitive speed of motion).
- Fitness. Well-conditioned individuals generally utilize oxygen more efficiently and can extract more oxygen from a given volume of air than unfit individuals, thereby slightly increasing the SCBA operating time.
- Body size. Larger individuals generally consume air at a higher rate than smaller individuals, thereby decreasing the SCBA operating time.
- Breathing patterns. Quick, shallow, or irregular breaths use air more rapidly than deep, regularly spaced breaths. Heat-induced anxiety and lack of acclimatization may induce hyperventilation, resulting in decreased SCBA operating time.

Suit/Ensemble Permeation, Degradation, and Penetration. The possibility of chemical permeation, degradation, or penetration of protective ensembles during the work mission is always a matter of concern and may limit mission duration. Possible causes are suit valve leakage, because of excessively hot or cold temperatures or improper maintenance, and exhalation valve leakage at excessively hot or cold temperatures.

Also, when considering mission duration, it should be remembered that no single clothing material is an effective barrier to all chemicals or all combinations of chemicals, and no material is an effective barrier to prolonged chemical exposure.



Ambient Temperature. The ambient temperature may have a major influence on work mission duration as it affects both the worker and the protective integrity of the ensemble. Heat stress, which can occur even in relatively moderate temperatures, presents the greatest immediate danger to an ensemble-encapsulated worker. Protecting against heat stress is discussed later in this chapter. Hot and cold ambient temperatures also can affect:

- Valve operation on suits and/or respirators;
- The durability and flexibility of suit materials;
- The integrity of suit fasteners;
- The breakthrough time and permeation rates of chemicals; and
- The concentration of airborne contaminants.

All of these factors may decrease the duration of protection provided by a given piece of clothing or respiratory equipment.

Coolant Supply. Under warm or strenuous work conditions, adequate coolant (e.g., ice or chilled air, refrigeration coils) should be provided to keep the wearer's body at a comfortable temperature and to reduce the potential for heat stress. If coolant is necessary, the duration of the coolant supply will directly affect mission duration.

5.2.3 Storage and Maintenance

Clothing and respirators must be stored properly to prevent damage or malfunction due to exposure to dust, moisture, sunlight, damaging chemicals, extreme temperatures, and impact. Many equipment failures can be directly attributed to improper storage. Procedures must be specified for both pre-issuance warehousing and, more importantly, post-issuance (in-use) storage.

Potentially contaminated, reusable clothing should be stored (generally bagged) in a well-ventilated area, with good air flow around each item, until the extent of contamination is documented. The garment is then either decontaminated or disposed. Never store these materials near street clothing.

Different types and materials of clothing and gloves should be stored separately to prevent issuing the wrong material by mistake. Protective clothing should be folded or hung in accordance with manufacturers' recommendations.

SCBAs, supplied-air respirators, and air-purifying respirators should be dismantled, washed, and disinfected after each use. SCBAs should be stored in storage chests supplied by the manufacturer. Air-purifying respirators should be stored individually in their original cartons or carrying cases, or in heat-sealed or resealable plastic bags.

The technical aspects of PPE maintenance procedures vary by manufacturer and type of equipment. Manufacturers frequently restrict the sale of certain PPE parts only to individuals or groups who are specially trained, equipped, and "authorized" by the manufacturer to purchase them. Explicit procedures should be adopted in the site work plan to ensure that the appropriate level of maintenance is performed only by individuals trained at that level.

The following classification scheme is often used to divide maintenance into three levels:

- **Level 1**: User or wearer maintenance, requiring a few common tools or no tools at all.
- **Level 2**: Shop maintenance that can be performed by the employer's maintenance shop.
- **Level 3**: Specialized maintenance that can be performed only by the factory or an authorized repair person.

5.2.4 Training and Proper Fitting

The PPE program must ensure that employees are trained in the proper use and fitting of PPE.

Training. Employees should be trained in the proper use of protective equipment prior to using any PPE on-site. The purpose of training is to: (1) become familiar with the equipment in a nonhazardous situation; (2) instill confidence and awareness in the user of the limitations and capabilities of the equipment; (3) increase the operating and protective efficiency of PPE use; and (4) reduce maintenance expenses.

Training must be completed prior to actual PPE use in any hazardous environment and should occur at least annually. At a minimum, the training portion of the PPE program should explain the user's responsibilities and should address the following issues, utilizing both classroom and field training when necessary:

- OSHA requirements as delineated in 29 CFR Part 1910, Subparts I and Z.
- OSHA requirements for respiratory protection at 29 CFR §1910.134.
- The proper use and maintenance of the selected PPE, including capabilities and limitations.
- The nature of the hazards and the consequences of not using PPE.
- Instruction in inspection, donning, doffing, decontaminating, checking, fitting, and using PPE.
- Individualized respirator fit testing to ensure proper fit.
- Use of PPE in normal air for a long familiarity period, as well as use of PPE in a test atmosphere to evaluate its effectiveness.

- The user's responsibility (if any) for decontamination, cleaning, maintenance, and repair of PPE.
- Emergency procedures and self-rescue in the event of PPE failure.
- The elements of the HASP and the individual's responsibilities and duties in an emergency, including the buddy system (see **Chapter 4**).
- The human factors influencing PPE performance. The discomfort and inconvenience of wearing PPE can create a resistance to the conscientious use of PPE. One essential aspect of training is to make the user aware of the need for PPE and to instill motivation for the proper use and maintenance of PPE.

Respirator Fit Testing. The "fit" of the facepiece-to-face seal of a respirator must be tested on each potential wearer to ensure a tight seal; every facepiece does not fit every wearer. Certain features, such as scars, very prominent cheekbones, deep skin creases, dentures or missing teeth, and the chewing of gum and tobacco may interfere with the respirator-to-face seal. Under conditions where these features may impede a good seal, a respirator must not be worn.

For a qualitative respirator fit testing protocol, see Appendix D of the OSHA lead standard (29 CFR §1910.1025). For specific quantitative testing protocols, literature supplied by manufacturers of quantitative fit testing equipment should be consulted.

5.2.5 Donning and Doffing Procedures

The PPE program should include clearly defined donning and doffing procedures.

Donning. A routine should be established and practiced periodically for donning all levels of protective clothing and equipment. As donning and doffing the ensembles can be difficult to perform alone and solo efforts increase the possibility of improper use and suit damage, assistance should be provided. The donning routine should be modified depending on the particular type of suit or the need for extra gloves or boots. Once the equipment has been donned, the fit should be evaluated. The clothing should not be too small, increasing the likelihood of tearing the suit material and accelerating worker fatigue, nor should it be too large, increasing the possibility of snagging the material and compromising the dexterity and coordination of the worker. In either case, better fitting clothing should be provided.

Doffing. Exact procedures for removing PPE must be established and followed to prevent contaminant migration from the work area and transfer of contaminants to the wearer's body, the doffing assistant, and others. These procedures should be performed only after decontamination of the suited worker (see **Chapter 9**). Although they require a suitably attired assistant, both worker and assistant should avoid any direct contact with the outside surface of the contaminated suit throughout the decontamination procedures. If the suit is to be reused, the assistant should also avoid contact with the inside of the garment.

5.2.6 Inspection Procedures

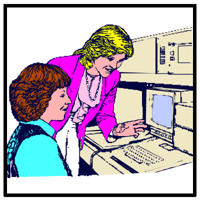
An effective PPE inspection program should feature four different inspections:

- Inspection and operational testing of equipment received from the factory or distributor;
- Inspection of equipment as it is issued;
- Inspection before and after use or training and prior to maintenance; and
- Periodic inspection of stored equipment.

The inspection checklist in **Exhibit 5-6** may be helpful in conducting inspections of PPE prior to and during regular use. Periodic inspection will cover somewhat different areas in varying degrees of depth. Detailed inspection procedures, where appropriate, are usually available from the manufacturer.

Individual identification numbers should be assigned to all reusable pieces of equipment and records must be maintained, by number, of all inspection procedures. At a minimum, each inspection should record the ID number, date, inspector, and any unusual conditions or findings.

5.2.7 PPE Program Evaluation



At a minimum, the PPE program should be reviewed annually to evaluate the effectiveness of the following factors:

- The number of personnel-hours that are spent in various PPE ensembles;
- The degree to which the site complies with the HAZWOPER standards on PPE use, inspection, maintenance, and record keeping;
- Accident, injury, and illness statistics, and recorded levels of exposure;
- The adequacy of operating procedures to guide the selection of PPE;
- The degree of coordination with comprehensive and site-specific health and safety programs; and
- Recommendations for and results of program improvement and modification

5.2.8 Other Considerations

There are other factors, not discussed above, that may also affect the use and effectiveness of PPE. Several of these factors, dealing with the physical state of the user, are discussed below.

Heat Stress. Wearing PPE puts a hazardous waste worker at considerable risk of developing heat stress, which can result in adverse health effects ranging from transient heat fatigue to serious illness or death. Heat stress is caused by a number of interacting factors, including environmental conditions, clothing, workload, and the individual characteristics of the worker. Heat stress is one of the most common and potentially serious illnesses at hazardous waste sites and, therefore, warrants regular monitoring and other preventive measures. **Chapter 8** provides more detailed information on heat stress and PPE.

Other Factors. Although wearing PPE decreases a worker's performance, the magnitude of this effect varies considerably, depending on both the individual and the PPE ensemble used. One of the physiological factors that may affect worker ability to function using PPE is physical fitness. The more fit someone is, the more work they can perform safely. At a given level of work, a fit person, relative to an unfit person, will have: less physiological strain; a lower heart rate; a lower body temperature, indicating less retained body heat; a more efficient sweating mechanism; slightly lower oxygen consumption; and slightly lower carbon dioxide production.

The degree to which a worker's body has adjusted or acclimatized to working under hot conditions may affect his or her ability to do work. Acclimatized individuals generally have better mechanisms to maintain lower skin and body temperatures at a given level of environmental heat and work loads. Although acclimatization can occur quickly, a progressive 6-day acclimatization period before allowing an employee to work a full shift on a hot day is recommended. With fit or trained individuals, the acclimatization period may be shortened by 2 or 3 days. Acclimatization can occur quickly, and work regimens should be adjusted to account for this.

EXHIBIT 5-6
Sample PPE Inspection Checklists

CLOTHING

Before use:

- Determine that the clothing materials are correct for the specified task at hand.
- Visually inspect for:
  - -- imperfect seams
  - -- non-uniform coatings
  - -- tears
  - -- malfunctioning closures
- Hold up to light and check for pinholes.
- Flex product:
  - -- observe for cracks
  - -- observe for other signs of shelf deterioration
- If the product has been used previously, inspect inside and out for signs of chemical attack:
  - -- discoloration
  - -- swelling
  - -- stiffness

During the work task, periodically inspect for:

- Evidence of chemical attack such as discoloration, swelling, stiffening, and softening. Keep in mind, however, that chemical permeation can occur without any visible effects.
- Closure failure.
- Tears.
- Punctures.
- Seam discontinuities.

GLOVES

Before use:

- Pressurize glove to check for pinholes. Either blow into glove, then roll gauntlet towards fingers or inflate glove and hold under water. In either case, no air should escape.

FULLY-ENCAPSULATING SUITS

Before use:

- Check the operation of pressure relief valves.
- Inspect the fitting of wrists, ankles, and neck.
- Check faceshield, if so equipped, for:
  - -- cracks
  - -- fogginess

RESPIRATORS*

SCBA

- Inspect SCBAs:
  - -- before and after each use
  - -- at least monthly when in storage
  - -- every time they are cleaned
- Check all connections for tightness.
- Check material conditions for:
  - -- signs of pliability
  - -- signs of deterioration
  - -- signs of distortion
- Check for proper setting and operation of regulators and valves (according to manufacturers' recommendations).
- Check operation of alarm(s).
- Check faceshields and lenses for cracks and fogginess

Air-Purifying Respirators

- Inspect air-purifying respirators:
  - -- before each use to be sure they have been adequately cleaned
  - -- after each use
  - -- during cleaning
  - -- monthly if in storage for emergency use
- Check material conditions for:
  - -- signs of pliability
  - -- signs of deterioration
  - -- signs of distortion
- Examine cartridges or canisters to ensure that:
  - -- they are the proper type for the intended use
  - -- the expiration date has not been passed
  - -- they have not been opened or use previously
- Check faceshields and lenses for cracks and fogginess

Supplied-Air Respirators

- Inspect supplied-air respirators:
  - -- daily when in use
  - -- at least monthly when in storage
  - -- every time they are cleaned
- Inspect air lines prior to each use for cracks, kinks, cuts, frays, and weak areas.
- Check for proper setting and operation of regulators and valves (according to manufacturers' recommendations).
- Check all connections for tightness.
- Check material conditions for:
  - -- signs of pliability
  - -- signs of deterioration
  - -- signs of distortion
- Check faceshields and lenses for cracks, fogginess

*** Must have NIOSH/MSHA approval**

FURTHER GUIDANCE: For more information on selecting, using, and maintaining PPE, see:

1. *Certified Equipment List as of December 31, 1990.* (NIOSH, 1991, Publication 91-105) Cincinnati, OH. Updated annually.

2. *Standard Operating Guidelines for Site Entry* (U.S. EPA, 1985, Publication 9285.2-01A).

3. Schwope, A.D.; Costas, P.P.; Jackson, J.O.; Stull, J.O.; and D.J. Weitzman, 1987, *Guidelines for the Selection of Chemical Protective Clothing, 3rd Edition.* American Conference of Governmental Industrial Hygienists, Inc. Cincinnati, OH.

4. *National Fire Codes: A Compilation of NFPA Codes, Standards, Recommended Practices and Guides, Vol.8.* (1991, National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02269-9101).

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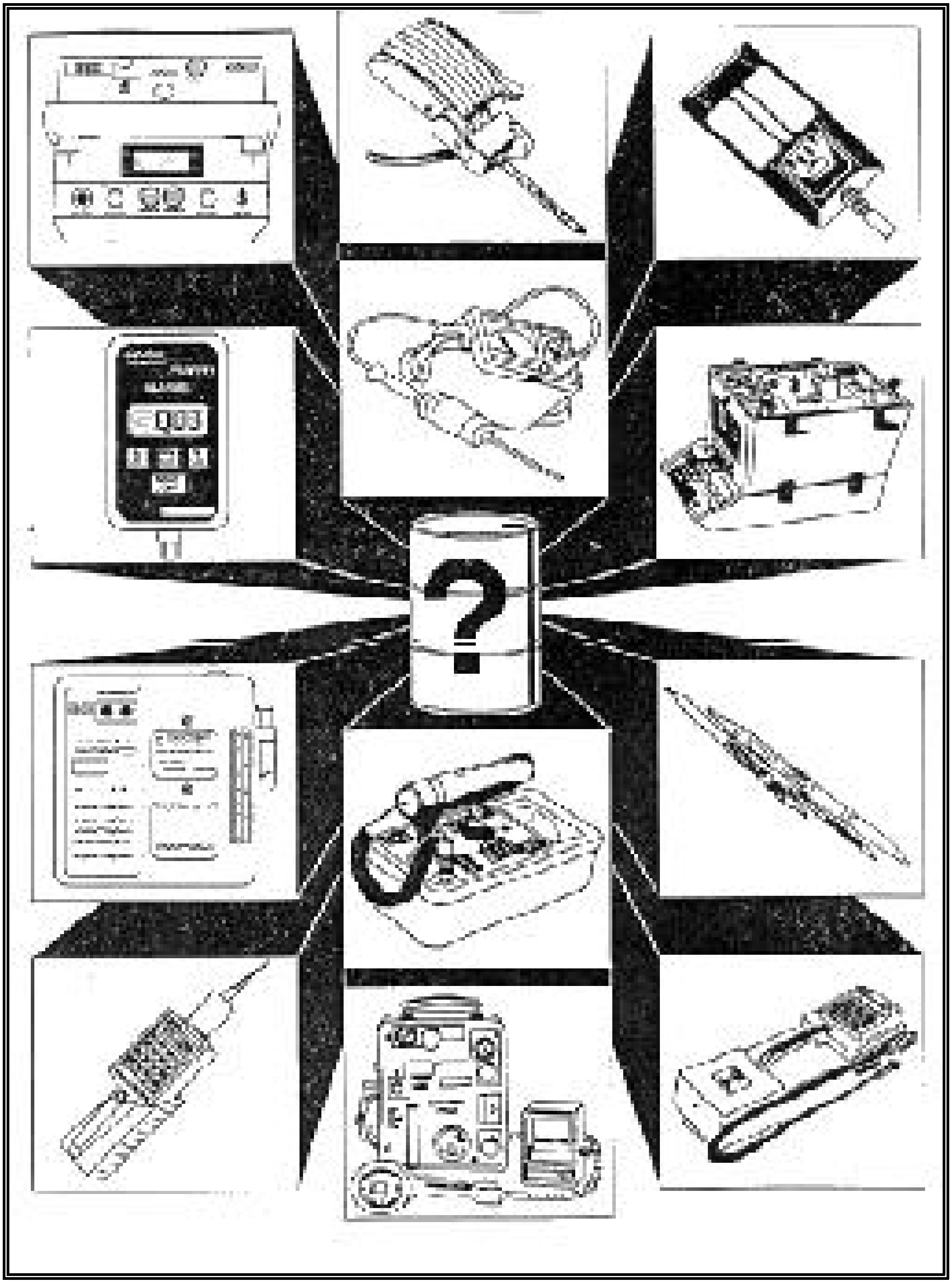
CHAPTER 6   AIR MONITORING



CHAPTER 6 AIR MONITORING

6.0 INTRODUCTION

The presence of hazardous materials at a site, as well as actions taken to address these materials, can cause the release of hazardous substances into the air. Chemical fires, transportation accidents, open or leaking containers, wind-blown dust, and site cleanup activities produce emissions that can rapidly affect the health and safety of response personnel and the public. Hazardous atmospheres can be:

- Explosive (characterized by the presence of ignitable or explosive vapors, gases, aerosols, and dusts);
- Toxic (characterized by the presence of vapors, gases, particulates, and aerosols);
- Oxygen-deficient (characterized by the displacement of breathable air); or
- Radioactive (characterized by the presence of radioactive materials).

The presence of one or more of these hazards is an important factor in determining subsequent actions that should be taken to protect people and the environment. Their presence may dictate operations that are necessary to mitigate the likelihood of an incident, and safety considerations for response personnel.

Airborne hazards can be predicted if the substance involved, its chemical and physical properties, and weather conditions are known. However, air monitoring is necessary to confirm predictions, to identify or measure contaminants, and to detect unknown air pollutants. Therefore, 29 CFR §1910.120(h) sets forth specific requirements for air monitoring. The remainder of this chapter describes the air monitoring requirements and outlines a number of practices that can be implemented to meet these requirements most effectively.

6.1 OBJECTIVES OF AIR MONITORING

The objectives of air monitoring during response operations are to:

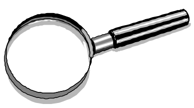
- Identify and quantify airborne contaminants on- and off-site;
- Track changes in air contaminants that occur over the lifetime of the incident;
- Ensure proper selection of work practices and engineering controls;
- Determine the level of worker protection needed;
- Assist in defining work zones; and
- Identify additional medical monitoring needs in any given area of the site.

HAZWOPER requires air monitoring to be performed wherever the possibility of employee exposure to hazardous substances exists. Upon initial entry, representative air monitoring should be conducted to identify any IDLH conditions, exposure over PELs, exposure over a radioactive material's dose limits, or other dangerous conditions, such as flammable or oxygen-deficient environments. Air monitoring should also be conducted to confirm that the area considered for the Support Zone is clean (i.e., does not contain concentrations of hazardous substances that require worker protection). If there is any question that contaminants may have migrated into the area considered for the Support Zone, air and/or surface soil samples should be collected and compared with on-site and off-site background samples.

To determine whether additional monitoring is required to designate work zones, the site manager should evaluate the results of the initial air monitoring survey, the visual characterization of site hazards, the properties of on-site contaminants, and potential pathways of contaminant dispersion. During the site hazard evaluation, the site manager should use information from direct-reading instruments, visible indicators (signs, labels, placards, etc.), and other sources (manifests, inventories, government agency records, etc.) to evaluate the presence or potential for the release of contaminants into the air. Limited air sampling may also be conducted if time is available. Based on an assessment of this preliminary information, a more comprehensive air monitoring strategy should be developed and implemented.

During the response operation, (e.g., when soil or containers are moved or disturbed), employers should monitor those employees likely to have the highest exposures to hazardous substances (i.e., exposures above PELs). In accordance with 29 CFR §1910.120(h)(4), if any employee has been exposed to elevated levels of hazardous substances, extensive personal monitoring must be conducted, in conjunction with additional site control measures, to ensure employee health and safety.

6.2 IDENTIFYING AIRBORNE CONTAMINANTS



The two methods generally available for identifying and/or quantifying airborne contaminants are: (1) on-site use of direct-reading instruments (DRIs); and (2) laboratory analysis of air samples obtained by gas sampling bag, filter, sorbent, or wet-contaminant collection methods.

DRIs may be used to quickly detect flammable or explosive atmospheres, oxygen deficiency, certain gases and vapors, and ionizing radiation, as well as to identify changing site conditions. Because DRIs provide information at the time of sampling and allow for rapid decision-making, they are the primary tools of initial site characterization. All DRIs, however, have inherent limitations in their ability to detect hazards. DRIs detect and/or measure only specific classes of chemicals and usually are not designed to detect airborne concentrations below 1 ppm. In addition, many of the DRIs that have been designed to detect one particular substance also detect other substances and, consequently, may give false readings. DRIs must be operated, and their data interpreted, by qualified individuals using properly calibrated instruments. Additional monitoring should be conducted at any location where a positive instrument response occurs.

Because DRIs are available for only a few specific substances and are rarely sensitive enough to detect low concentrations of hazardous substances that may nonetheless present health risks, long-term or "full-shift" air samples must also be collected and analyzed in a laboratory. Full-shift air samples for some chemicals may be collected with passive dosimeters, or by means of a pump that draws air through a filter or sorbent.

Selection of the proper sampling media is determined by the physical state of the contaminants. Some chemicals, such as PCBs, may occur as both vapors and particulate-bound contaminants. In such cases, a dual-media system is needed to measure accurately for the chemical.

6.2.1 Direct Reading Instruments

During site operations, it is essential to monitor for the presence of, or changes in, the level of airborne contaminants. Changes in contaminant levels may occur when work is initiated in a different area of the site, new contaminants are discovered, or different types of operations are begun in a particular area (e.g., drum opening, as opposed to exploratory well drilling). DRIs can be used to provide approximate total concentrations of many organic chemicals and a few inorganic substances. If specific organics (and inorganics) have been identified, then DRIs calibrated to those materials can be used for more accurate on-site assessment.

To obtain air monitoring data rapidly at the site, monitoring personnel may use instruments with flame ionization detectors (FIDs), photo-ionization detectors (PIDs), and other similar instruments. These may be used as survey instruments (total concentration mode), or operated as gas chromatographs (gas chromatograph mode). As gas chromatographs, these instruments can provide real-time, qualitative/quantitative data when calibrated with standards of known air contaminants. Combined with selective laboratory analysis of samples, they provide an excellent tool for evaluating airborne organic hazards on a real-time basis, at a lower cost than analyzing all samples in a laboratory. **Exhibit 6-1** lists several direct-reading air monitoring instruments, and **Appendix D** presents more specific information on the characteristics of the PID and the organic vapor analyzer (OVA).

EXHIBIT 6-1
Summary of Direct-Reading Air Monitoring Instruments

Principle of Detection and Monitoring Need	Instrument	Features	Limitations
Wheatstone Bridge Filament *Monitoring Need:* ***Combustible Gas***	Combustible Gas Detector	• Nonspecific detector for combustible gases measures gas concentrations as a percentage of lower explosive limit (LEL) • Lightweight, portable, and easy to use • Visual and audible alarms • Probe provides remote sensing capabilities • 8- to 12-hour battery operating life for most models • Accuracy varies depending upon the model; accuracies of ± 2 to 3 percent are attainable	• Potential interferences from leaded gasoline and silicates, which are more strongly adsorbed on catalyst than oxygen or gas in question. Membranes are available to minimize these effects. • Most models do not measure specific gases • May not function properly in oxygen-deficient atmospheres (<10 percent)
Chemical Cell *Monitoring Need:* ***Oxygen Deficiency***	Oxygen Meter	• Direct readout in percent oxygen • Visual and audible alarm • Lightweight, portable, and easy to use • Probe provides remote sensing capabilities • Accuracies of ± 1 percent are attainable, but depend on the particular model • Generally 8- to 10-hour battery life	• High humidity may cause interference • Strong oxidants may cause artificially high readout
Chemical Sensor Wheatstone Bridge Filament *Monitoring Need:* ***Combustible Gas/Oxygen Deficiency***	Combination Oxygen Meter and Combustible Gas Detector	• Calibrated to Pentane or Hexane • Measure percent oxygen and gas concentration as a percentage of LEL • Both visual and audible alarm • Remote sensing capabilities • Lightweight, portable, and easy to use • Accuracies of ± 2 percent are attainable but may be as high as ± 10 percent, depending on the models	• Same limitation as oxygen meters and combustible gas detectors • In certain units, acid gases and high CO_2 concentrations shorten the life of oxygen sensor/cells • Certain units require conversion factor for true specific compound response readings • In certain units, oxygen calibration is altitude dependent
Optical, Electrical, Piezoelectric *Monitoring Need:* ***Aerosol/ Particulate***	Aerosol/ Particulate Monitor	• Selectable ranges • Particle size differentiation available • Certain units have data logging capabilities	• Factory recalibration required on certain units • Values represent total particulates: dust, mist, aerosols are all inclusive with no differentiation • Cold weather may have adverse effect on detector

Summary of Direct-Reading Air Monitoring Instruments

Principle of and Monitoring	Instrument	Features	
Photoionization *Monitoring Need:* ***Vapors***	Photoioni-zation	• Nonspecific gas and vapor inorganics • gases • portable • Sensitivity is related to ionization potential of compound Remote sensing capabilities • less than 3 seconds • unsaturated compounds that the flame ionization detector (FID) 8-hour battery operating life; certain units with external interchangeable • Audible alarm is available Certain units have data logging/computer interface • Certain units available with • Certain units available with	• Does not monitor for specific gases or • Cannot detect hydrogen cyanide or • Cannot detect some chlorinated • High humidity and precipitation
Hydrogen Flame Ionization *Need:* ***Toxic Gas/***	Flame Ionization	• In the survey mode, it functions as analyzer; in the gas chromatograph mode, it provides tentative • Most sensitive to saturated unsaturated hydrocarbon alkanes • • Remote sensing probe is available Response time is 90 percent in 2 seconds 8-hour battery operating life • predetermined levels are exceeded	• Cl_2 $_3$) Less sensitive to aromatics and unsaturated compounds than PID Requires skilled technicians to operate the equipment in the GC mode and to • Requires changes of columns and gas in certain units • and calibration columns are needed, the operator must have some idea of • Substances that contain substituted or (Cl-) Chloride groups) reduce the detector's sensitivity

EXHIBIT 6-1
Summary of Direct-Reading Air Monitoring Instruments

Principle of Detection and Monitoring Need	Instrument	Features	Limitations
Infrared Radiation *Monitoring Need:* ***Toxic Gas/ Vapors***	Infrared Analyzer	• Overcomes the limits of most infrared (IR) analyzers by use of a variable filter; can be used to scan through a portion of the spectrum to measure concentration of several gases or can be set at a particular wavelength to measure a specific gas • Detects both organic and inorganic gases • Portable but not as lightweight (32 lbs.) as the photoionization or the flame ionization detectors	• Not as sensitive as PID or the FID • Less portable than other methods of gas/vapor detection • Requires skilled technicians to operate and analyze results when positive identification is needed • Interference by water vapor and carbon dioxide • Most require AC power source • Positive identification requires comparison of spectrum from strip chart recorder with published adsorption spectrum; infrared spectrum not available for all compounds
Chemical Reaction Producing a Color Change *Monitoring Need:* ***Toxic Gas/ Vapors***	Indicator Tubes	• Provides qualitative, semi-quantitative identification of volatile organics and inorganics • Accuracy of only about ± 25 percent • Simple to use, and relatively inexpensive • Real-time/semi-realtime results	• Low accuracy • Subject to leakage during pumping • Requires previous knowledge of gases/vapors in order to select the appropriate detector tube • Some chemicals interfere with color reaction to read false positive • Temperature and humidity may affect readings
Electrochemical Cell *Monitoring Need:* ***Toxic Gas/ Vapors Specific Atmospheres***	Toxic Atmosphere Monitor	• Ease of operation • Small, compact, lightweight • Audible alarm upon exceeding present action level or TLV • Certain units have digital readout • Generally compound-specific • Certain units interface with data logger	• Cross sensitivity • Slow response/recovery after exposure to high contamination levels • Limited number of chemicals detected
Metal-Oxide Semiconductor *Monitoring Need:* ***Toxic Gas/ Vapors***	Toxic Atmosphere Monitor	• Ease of operation • Small, compact, lightweight • Audible alarm upon exceeding present action level or TLV • Certain units have digital readout • Certain units interface with data logger • Nonspecific gas and vapor detection for some organics and inorganics	• Cross sensitivity • Slow response/recovery after exposure to high contamination levels

EXHIBIT 6-1
Summary of Direct-Reading Air Monitoring Instruments

Detection and Need	**Instrument**		**Limitations**
Monitoring Need:	Radiation Meters	Measures radiation in mR/hr (battery operated) Probe provides remote sensing capabilities Accuracy and sensitivity varies considerably with manufacturer and • A variety of meters are available. radiation; others are specific for gamma, alpha, or a combination of	• Some meters do not determine type of
Gold Film Sensor *Monitoring* ***Mercury Vapor***	Mercury Vapor	• Compound specific; has survey • 0.001 mg/m detection limit • saturated sensor cleaning capabilities Can be used with dosimeters for on-site dosimetry Microprocessor serves reading; automatically re-zeros Certain units have data logging capabilities 5-hour battery life	• factory recalibration Short battery life • Cycle

Mathamel, 1981; Spittler, 1980; McEnery, 1982; National Mine Service Company, 1980; Gas-Tech, 1980; Enmet Corporation,

6.2.2 Air Sampling

For
contaminants, measurements obtained with DRIs be supplemented with air samples. To assess
sampling devices equipped with appropriate media should be placed at various locations
provide air quality information, and can indicate the
over the lifetime of site operations. As data are (from the analysis of samples, DRIs, and site
the type and number of samples, frequency of and analysis required. In addition to air samplers,
include DRIs equipped with recorders and

as continuous air monitors. Area sampling
following locations:

Upwind Because many hazardous incidents occur
air pollutants, samples must be taken upwind of

sources of contaminants, to establish background

Support . Samples must be taken near command post or other support facilities to ensure
area, and that the area remains clean throughout

Contamination Reduction Zone. Air samples should be collected along the Contamination Control Line to ensure that personnel are properly protected and that on-site workers are not removing their protective gear in a contaminated area.

Exclusion Zone. The Exclusion Zone presents the greatest risk of exposure to chemicals and requires the most air sampling. The location of sampling stations should be based upon hot spots or source areas detected by DRIs, types of substances present, and potential for airborne contaminants. The data from these stations, in conjunction with intermittent walk-around surveys with DRIs, should be used to verify the selection of proper levels of PPE and to set Exclusion Zone boundaries, as well as to provide a continual record of air contaminants.

Fenceline/Downwind. Sampling stations should be located downwind from the site to determine whether any air contaminants are migrating from the site. If there are indications of airborne hazards in populated areas, additional samplers should be placed downwind.

In many instances, only air sampling and laboratory analysis are necessary for detection and quantification. Although accurate, the air sampling and laboratory analysis option has two disadvantages: cost and time. Analyzing large numbers of samples in laboratories is expensive, especially when results are needed quickly. On-site laboratories tend to reduce the turn-around time, but their cost may be prohibitive.

6.3 AIR SAMPLING EQUIPMENT AND MEDIA

A variety of air sampling equipment may be used to collect samples of potentially dangerous substances that may become airborne at hazardous waste sites. Sampling systems typically include a calibrated air sampling pump that draws air into selected collection media. Some of the most common types of sampling and collection media are described below:

Organic Vapors. Activated carbon is an excellent sorbent for most organic vapors. However, other solid sorbents (such as Tenax®, silica gel, and Florisil®) are routinely used to sample specific organic compounds or classes of compounds that do not adsorb or desorb well on activated carbon. The samples should be collected using an industrial hygiene personal sampling pump with either one sampling port or a manifold system capable of simultaneously collecting samples on several sorbent tubes. Individual pumps with varying flow rates may also be used to collect several samples at once. The sorbent tubes may contain:

- Activated carbon, to collect vapors of materials with a boiling point above zero degrees centigrade. These materials include most solvent vapors.

- A porous polymer, such as Tenax® or Chromosorb® to collect substances that adsorb poorly onto activated carbon (e.g., high-molecular-weight hydrocarbons, organo-phosphorus compounds, and the vapors of certain pesticides). Some of these porous polymers also adsorb organic materials at low ambient temperatures more efficiently than carbon.

- A polar sorbent, such as silica gel to collect organic vapors that exhibit a relatively high dipole movement (e.g., aromatic amines).

- Any other specialty adsorbent selected for the specific site (e.g., a Florisil® tube, if PCBs are suspected).

Inorganic Gases. The inorganic gases present at a site would primarily be polar compounds such as the haloacid gases and ammonia. These gases can be adsorbed onto silica gel tubes and analyzed by ion chromatography. Impingers filled with selected liquid reagents can also be used.

Aerosols. Aerosols (solid or liquid particulates) that may be encountered at an incident include contaminated and non-contaminated soil particles, heavy-metal particulates, pesticide dusts, and droplets of organic or inorganic liquids. An effective method for sampling these materials is to collect them on a particulate filter, such as a glass fiber or mixed cellulose fiber membrane. A backup impinger filled with a selected absorbing solution may also be necessary.

Colorimetric detector tubes can also be used with a sampling pump when monitoring **specific** compounds. **Exhibit 6-2** lists several air collection and analytical methods.

6.4 SAMPLE COLLECTION AND ANALYSIS

Samples are analyzed to determine types and quantities of substances present at a site. Good sources of information on collecting and analyzing samples for a variety of chemical substances include: (1) *EPA's Compendium of Methods for Determination of Toxic Organic Compounds in Air,* (2) the National Institute for Occupational Safety and Health's (NIOSH) *Manual of Analytical Methods,* (Volumes 1-3, 4th Edition); and (3)

OSHA Analytical Methods. references may be
provides additional guidance on sample collection

Aerosols.
taken at a relatively high flow rate (generally

industrial hygiene pump and filter assembly. To collect
a 0.8 micrometer pore size is common. The sample
particulates, then analyzed destructively or non-
for metals. If a non-destructive metals
sectioned, additional analyses (e.g., organics,
and optical particle sizing) can be performed.

Samples.
chosen, the amount used, and sample volume will
according to the types and concentrations of
substances anticipated at a
sorbent material such as silica gel will collect polar substances
activated carbon and some of the porous
T'he silica gel sample can be split and analyzed
amines.
Activated carbon and porous polymers will

analysis to identify and quantify all the collected
is prohibitively expensive at any
laboratory and technically difficult for a field
Therefore, samples should be
analyled for principal hazardous constituents
The selection of PHCs should be based
on the types of materials anticipated at a given
and on information collected during the initial
site survey. To aid in the selection of PHCS, a
could be collected on activated carbon or
porous polymer during the initial site survey and

peaks within selected categories. This particular analysis, along with
a particular site, could provide enough information
select PHCS. Standards of PHCs could then be
used for field analysis of samples. Subsequent, routine,
scanning for only PHCS, saving time and
urces. Special adsorbents and sampling condition
desired while continued multi-media sampling
a base for analysis of additional PHCs that
cleanup operations.

Passive . A less traditional
of sampling is the use of passive
dosimeters. The few passive dosimeters now
are for gases and vapors only. Although pa
personal exposure, they also can be used to
areas. Passive monitors are divided into
two groups:

Diffusion . in which molecules
across a concentration gradient,
achieved within a
stagnant layer of air,
contaminated atmosphere and the

- ation devices,
natural permeation of a contaminant
a membrane. A suitable membrane
permeated by the contaminant of interest

Permeation dosimeters, therefore, are
in picking out a single contaminant from
contaminants.

Some
are DRIs and calorimetric length-of-stain tubes.
require laboratory analysis similar to that
conducted on solid sorbents.

sampling should be conducted using a variety
airborne contaminants and their concentrations.
'he following sampling pattern can be used as a guideline.
possible generation, air samples should be
downwind from the designated source along the
proceed upwind to a point as close as possible to
source. Level B protection (see Section 6.9.3) should
and the potential for an unexpected release of

After reaching the source, or finding the highest
along the cross-axis of the wind direction to
the degree of dispersion. Smoke plumes,
airborne substances, may be released as an aid in
assessment. To ensure that there is no background
substance(s) originate from the identified source,
samples also should be collected upwind from
the source.

Fixed-location monitoring at the "fenceline" or
where PPE is no longer required, measures

site and enables the Site Health and Safety Officer to evaluate the integrity of the site's clean areas. Because the fixed-location samples may reflect exposures either upwind or downwind from the site, wind speed and direction data are needed to interpret the sample results.

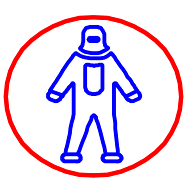
6.5.2 Periodic Monitoring

Site conditions and atmospheric chemical conditions may change following the initial characterization. Periodic monitoring should be conducted when the possibility of a dangerous condition has developed or when there is reason to believe that exposures may have risen above PELs since prior monitoring was conducted. 'ne possibility that exposures have risen should be seriously considered when:

- Work begins on a different portion of the site;during this initial sampling. Levels of protection for subsequent sampling should be
- Different contaminants are being handled;
- A markedly different type of operation is initiated (e.g., barrel opening as opposed to exploratory well drilling); or
- Workers are handing leaking drums or working in areas with obvious liquid contamination (e.g., a spill or lagoon).

6.5.3 Personal Monitoring

The selective monitoring of high-risk workers (i.e.,those who are closest to the source of contaminant generation) is required by 29 CFR §1910. 120(h). This requirement is based on the probability that significant exposure varies directly if workers are in teams, a different monitoring device can be assigned to each team member. Another method is to place multiple sampling devices on pieces of heavy equipment. While these are not personal samples, they can be collected very close to the breathing zone of the heavy equipment operator and thus would be



dispersion and concentration need wind speed and direction as inputs for predictive calculations. Information may be needed concerning the reasonably representative of personal exposures. These multimedia samples can yield as much information as several personal samples.

6.6 METEOROLOGICAL CONSIDERATIONS

Meteorological information is an integral part of any air monitoring progranl Data concerning wind speed and direction, temperature, barometric pressure, and humidity, singularly or in combination', are needed for selecting air sampling locations, calculating air dispersion, calibrating instruments, and determining population at risk of exposure from airborne contaminants. Knowledge of wind speed and direction is necessary to effectively place air samplers. In source-oriented ambient air sampling, it is particularly important that samplers be located at varying distances downwind from the source. Similarly, it is important that background air samples be collected upwind from the source.

Samplers should be relocated or adjusted to reflect shifts in wind direction. In addition, atmospheric simulation models for predicting contaminant

frequency and intensity of winds from certain directions (windrose data). Consequently, wind direction must be monitored continually.

with distance from the source. If workers closest to the source are not significantly exposed, then other workers, presumably, are not significantly exposed and should not need to be monitored.

Because occupational exposures are linked closely with active material handling, personal air sampling is not necessary until site operations have begun. Thus, monitoring of those employees likely to have the highest exposures to hazardous substances and health hazards is not required until the actual cleanup phase commences (e.g., when soils, surface waters, or containers are moved or disturbed). Personal monitoring samples should be collected in the breathing zone and, if workers are wearing respiratory protective equipment, outside the facepiece. These samples represent the actual inhalation exposure of workers who are not wearing respiratory protection and the potential exposure of workers who are wearing respirators. Sampling should occur frequently enough to characterize employee exposures. If any employee is cwsed to concentrations over PELS, monitoring must continue to ensure the safety of all employees likely to be exposed to concentrations above those limits.

Personal monitoring may require the use of a variety of sampling media. Unfortunately, single workers cannot carry multiple sampling media because of the added strain and because it is not usually possible to draw air through different sampling media using a single portable, battery-operated pump. Consequently, several days may be required to measure the exposure of a specific individual using each of the media. Alternatively, Air sampling systems need to be calibrated before use and corrections in the calibration curves made for temperature and pressure. After sampling, sampled air volumes should also be coffected for temperature and pressure variations.

This requires data on air temperature and pressure during sampling.

Data may be collected from on-site meteorological stations or from government or private organizations that routinely collect meteorological data. The site manager should base data collection decisions on the availability of reliable data at the site, the resources needed to obtain meteorological equipment, the level of confidence required for the data, and the ultimate use of the data.

6.7 LONG-TERM AIR MONITORING PROGRAMS

A variety of long-term air monitoring programs can be designed to detect a wide range of airborne compounds. A number of factors should be considered before implementing any program, including type of equipment, costs, personnel, accuracy of analysis, time to obtain results (turn-around time), and availability of analytical laboratories.

for initial detection of total organic gases and vapors and for periodic site surveys (for total organics). Equipped with strip chart recorders, the detectors are used as area monitors to record total organic concentrations and changes in concentration over a period of time. Calibrated to specific organic contaminants, they are used to detect and measure those substances· Collecting area air samples using personal pumps and organic gastvapor collection tubes**.** Samples are analyzed using the gas chromatograph (GC) capabilities of field instruments. Selected samples are also analyzed in laboratories accredited by the American Industrial Hygiene Association (AIHA)-One approach to air monitoring, developed and used by the ERT, is described here. This program achieves a reasonable balance between cost, accuracy, and time in obtaining data using a combination of DRIs and air sampling systems. The data is used to survey for airborne organic vapors and gases, to identify and measure organic vapors and gases, and to identify and measure when developing an air monitoring program and when analyzing data. Some of the more important variables include:

- Using PIDs and/or FIDs (as a survey instrument or GC) to provide real-time data and to screen the number of samples needed for laboratory analysis.
- Sampling for particulates, inorganic acids, aromatic amines, halogenated pesticides, etc., when they are known to be present or when there are indications that these substances may be a problem.
- Using flame ionization detectors (FIDS) and/or photoionization detectors (PIDS)particulates and inorganic vapors and gases. The ERT approach is based on:
- Using flame ionization detectors (FIDS) and/or photoionization detectors (PIDS)

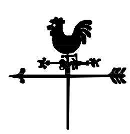
6.8 VARIABLES IN HAZARDOUS WASTE SITE AIR MONITORING

Complex environments involving numerous substances, such as those associated with hazardous waste sites, pose significant challenges to accurately and safely assessing airborne contaminants. Several independent and uncontrollable variables, most notably temperature and weather conditions, can affect airborne concentrations. These factors must be considered

Temperature. An increase in temperature increases the vapor pressure of most chemicals

Wind Speed. An increase in wind speed can affect vapor concentrations near a free-standing liquid surface. Dusts and particulate-bound contaminants are also affected.

Rainfall. Water from rainfall can essentially cap or plug vapor emission routes from open or closed containers,saturated soil, or lagoons, thereby reducing airborne emissions of certain substances.
Moisture. Dusts, including finely divided hazardous solids, are highly sensitive to moisture content. This moisture content can vary significantly with respect to location and time and can also affect the accuracy of many sampling results.



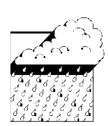


EXHIBIT 6-2
Summary of Common Air Collection/Analytical Methods

Contaminant	Collection Media	Collection Method*	Analytical Method
Alcohols	Charcoal	NIOSH 1400 NIOSH 1401 NIOSH 1402	GC-FID
Aliphatic Amines	Silica Gel	NIOSH 2010	GC-FID
Aromatic Amines	Silica Gel	NIOSH 2002	GC-FID
Asbestos	25 mm 0.8 gm MCEF filter 25 mm 0.45 itm MCEF filter	NIOSH 7400 NIOSH 7402	PCM TEM
Cyanides	0.8 jim MCEF filter and impinger	NIOSH 7904	ISE
Dioxin	3" polyurethane foam plug/filter	EPA TO-9	GC/MS
Hydrocarbons: BP **36-126,C** Aromatic Halogenated	Charcoal	NIOSH 1500 NIOSH **1501** NIOSH 1003	GC-FID EPA Modified GC/MS
Inorganic Acids	Washed Silica Gel	NIOSH 7903	IC
Mercury	Hopcolite/Hydrar	NIOSH 6009	AA
Metals (elements)	37 mm 0.8 jim MCEF filter	NIOSH 7300	ICP-AES
PCBs	Florisile and 13 mm glass fiber filter	Lewis/McCleod Modified NIOSH 5503	GC-ECD
Pesticides/PCBs	3" polyurethane foam plug	EPA TO-4	GC-ECD
Polyaromatic Hydrocarbons (PAH)	Washed XAD-2, 37 mm PTFE filter w/support 0-ring	NIOSH 5515	GC-PID
	2" x 1" Polyurethane Foam	NIOSH 5506	HPLC-UV
Volatile organics	Tenaxe/carbonized molecular sieve (CMS)	EPA TO-1 EPA TO-2	GC-MS
Volatile organics	SUMMAs canister, SUMMAE canister w/critical orifice	EPA TO-14	GC-ECD, NPD or FID GC/MS

LEGEND:
AA: Atomic Absorption
GC-ECD: Gas Chromatography-Electron Capture Detector
GC-FID: Gas Chromatography-Flame Ionization Detector
NPD: Nitrogen-Phosphorus Detector
GC-MS: Gas Chromatography
IC: Ion Chromatography
ICP-AES: Inductively Coupled Argon Plasma, Atomic Emission Spectroscopy
ISE: Ion Specific Electrode
PCM: Phase Contrast Microscopy
TEM: Transmission Electron Microscopy
HPLC-UV: High-Pressure Liquid Chromatography with UV Detector

Note: The flow rates that appear in the NIOSH methods are often modified for outdoor ambient air sampling.
Suspected carcinogens, particulates, highly hazardous substances, infectious wastes, or other substances that do not elicit an instrument response may be lmown or suspected to be present. Therefore, the protection level should not be based solely on the total vapor/gas criterion.

Rather, the level should be selected on a case-by-case basis, with special emphasis on potential exposure from the chemical and toxicological characteristics of the known or suspected material.

<u>Vapor Emissions.</u> The physical displacement of saturated vapors can produce short-term, relatively high, <u>vapor</u> concentrations. Continuing evaporation and/or diffasion may produce long-term low vapor concentrations and may involve large areas.

<u>Work Activities.</u> Work activities often require the mechanical disturbance of contaminated materials, which may change the concentration and composition of airborne contaminants.

6.9 USING VAPOR/ GAS CONCENTRATIONS TO DETERMINE LEVEL OF PROTECTION

The objective of using total atmospheric vapor/gas concentrations is to determine a numerical criterion for selecting the appropriate level of PPE (e.g., Level A, B, or C). In situations where the presence of vapors or gases is not known, or if present, the individual components are unknown, personnel required to enter that environment must be protected. Total vapor/gas concentration can be used as a guide for selecting PPE until more definitive criteria can be determined (e.g., until the constituents and atmospheric concentrations of vapor, gas, or particulates can be determined, and until respiratory and body protection can be chosen that relate to the toidcological properties of these constituents.)

Although total vapor/gas concentration measurements are useful to a qualified professional for the selection of protective equipment, caution should be exercised in their interpretation. An instrument does not respond with the same sensitivity to several vapor/gas contaminants as it does to a single contaminant. Also, because total vapor/gas field instruments detect all contaminants in relation to a specific calibration gas, the concentration of unknown gases or vapors may be either overestimated or underestimated.

6.9.1 Factors for Consideration

A number of factors should be considered when using total atmospheric vapor/gas concentrations as a guide for monitoring a selected Level of Protection. First, the uses, limitations, and operating characteristics of the monitoring instruments must be recognized and understood. Instruments such as the photoionization detector (PID), flame ionization detector (FID), and others do not respond identically to the same concentration of a substance; nor do they respond to <u>all</u> substances. Therefore, experience, knowledge, and good judgement must be used to complement the data obtained with instruments.

Second, other hazards may exist such as gases not detected by the PID or FID (i.e., phosgene, cyanides, arsenic, chlorine), explosives, flammable materials, oxygen deficiency, liquid/solid particles, and liquid or solid chemicals. Vapors and gases with a very low Threshold Limit Value (TLV) or IDLH value could also be present. Total readings on instruments not calibrated to these substances may not indicate unsafe conditions.

The risk to personnel entering an area must be weighed against the need for entering. Although this assessment is largely a value judgment, it requires a conscientious balancing of the known and potential risks to personnel against the need to enter an unknown environment.

The knowledge that suspected carcinogens or extremely toxic substances are present requires an evaluation of a number of factors, such as the potential for exposure, chemical characteristics of the materials present, and the limitations of monitoring instruments and PPE relative to the tasks that must be done on-site.

On-site activities must be evaluated to choose the correct level of PPE. Based upon total atmospheric vapor concentrations, Level C protection may be judged adequate; however, tasks such as moving drums, opening containers, and bulking of materials, which increase the probability of liquid splashes or generation of vapors, gases, or particulates, will likely require a higher level of protection.
The following sections provide information on levels of protection (refer to **Chapter 5** for more information on selecting PPE).

6.9.2 Level A Protection (500 to 1,000 ppm)

Level A protection provides the highest degree of respiratory tract, skin, and eye protection if the inherent limitations of the PPE are not exceeded. Although Level A provides protection against air concentrations greater than 1,000 ppm for most substances, an operational restriction of 1,000 ppm is established as a warning flag to:

- Evaluate the need to enter environments with unknown constituents at concentrations greater than 1,000 ppm;

- Identify the specific chemical constituents contributing to the total concentration and their associated toxic properties;

- Determine more precisely the concentrations of constituent chemicals;

- Evaluate the calibration and/or sensitivity error associated with the instrument(s); and

- Evaluate instrument sensitivity to wind velocity, humidity, temperature, etc.

A limit of 500 ppm total vapors/gases in air was selected as the value at which to upgrade from Level B to Level k This concentration was selected to fully protect the skin until the constituents can be identified and measured and substances affecting the skin are excluded. The range of 500 to 1,000 ppm is sufficiently conservative to provide a safe margin of protection if readings are low due to instrument error, calibration, and sensitivity; if higher than anticipated concentrations occur; and if substances highly toxic to the skin are present.

Ambient air concentrations approaching 500 ppm have not routinely been encountered on hazardous waste sites. Such high concentrations have been encountered only in closed buildings, when containers were being opened, when personnel were working in the spilled contaminants, or when organic vapors/gases were released in transportation accidents. A decision to require Level A protection should also consider the negative aspects: higher probability of accidents due to cumbersome equipment, and most importantly, the physical stress caused by heat buildup in fully encapsulating suits.

6.9.3 Level B Protection (5 to 500 ppm)

Level B protection is the minimum level of protection recommended for initially entering an open site where the type, concentration, and presence of airborne vapors are unknown. This level of protection provides a high degree of respiratory protection. Skin and eyes are also protected, although a small portion of the body (neck and sides of head) may be exposed. The use of a separate hood or hooded, chemical-resistant jacket would further reduce the potential for exposure to this area of the body. Level B impermeable protective clothing also increases the probability of heat stress.

A limit of 500 ppm total atmospheric vapor/gas concentration on portable field instruments has been selected as the upper restriction on the use of Level B. Although Level B PPE should be adequate for most commonly encountered substances at air concentrations higher than 500 ppm, this limit has been selected as a decision point for a careful evaluation of the risks associated with higher concentrations. The following factors should be considered when selecting Level B protection:

- The necessity for entering environments with unknown constituents at concentrations higher than 500 ppm wearing Level B protection;

- The probability that substance(s) present pose severe skin hazards;

- The work to be done and the increased probability of exposure;

- The need for qualitative and quantitative identification of the specific components;

- Inherent limitations of the instruments used for air monitoring; and

- Instrument sensitivity to winds, humidity, temperature, and other factors.

6.9.4 Level C Protection (Background to 55 ppm)

Level C provides skin protection identical to Level B, assuming the same type of chemical protective clothing is worn, but lesser protection against inhalation hazards. A range of background to *5* ppm above ambient background concentrations of vapors/gases in the atmosphere has been established - as guidance for selecting Level C protection. Concentrations in the air of unidentified vapors/gases approaching or exceeding 5 ppm would warrant upgrading respiratory protection to a self-contained breathing apparatus.

A full-face, air-purifying mask equipped with an organic vapor canister (or a combined organic vapor/particulate canister) provides protection against low concentrations of most common organic vapors/gases. There are some substances against which full-face, canister equipped masks do not protect, for example, substances with very low T'hreshold Limit Values (TLV) or IDLH concentrations. Many of the latter substances are gases or liquids in their normal state. Gases would only be found in gas cylinders, while the liquids would not ordinarily be found in standard containers or drums.

Every possible effort should be made to identify the individual constituents (and the presence of particulates) contributing to such low total vapor readings. Respiratory protective equipment can then be selected accordingly. It is exceedingly difficult, however, to provide constant, real-time identification of all components with concentrations of less than 5 ppm in a vapor cloud at a site where ambient concentrations are constantly changing.

If highly toxic substances have been ruled out, but ambient levels of less than 5 ppm persist, it is unreasonable to assume only self-contained breathing apparatus should be worn. The continuous use of air-purifying masks in such low vapor/gas concentrations gives a reasonable assurance that the respiratory tract is protected, provided that the absence of highly to)dc substances has been confirmed. Full-face, air-purifying devices are capable of providing respiratory protection against most vapors at greater than 5 ppm; however, until definitive qualitative information is available, a concentration of greater than 5 ppm requires that a higher level of respiratory protection be used.

Also, unanticipated transient excursions may increase the concentrations in the environment above the limits of air-purifying devices. The increased probability of exposure due to the work being done may require Level B protection, even though ambient levels are low.

FURTHER GUIDANCE: For more information on air monitoring equipment and procedures, see:

1. *Standard Operating Guide for Air Sampling and Monitoiing at Emergency Responses* (U.S. EPA, draft, Publication 9285.2-03A).

2. *Standard Operating Guide for the Use of Air Monitoring Equipment for Emergency Response (U.S.* EPA, draft, expected Summer 1992).

3. *Manual of Analytical Methods, (Volumes 1-3, 3rd Edition, with supplements)* (NIOSH, 1989, Publication 89-127).

4. *Compendium* of *Methods* for *Determination* of Toxic Organic Compounds in Air (U.S. EPA, 1987, EPA 600/4-87/006).

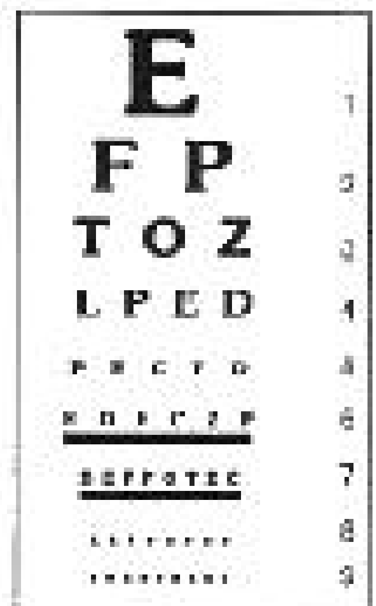
5. *OSHA Analytical Methods.* The OSHA Technical Center maintains an updated database of analytical testing methods. Printouts of analytical methods for individual chemicals are available by request. Contact the OSHA Technical Center, 1781 South 300 West, Salt Lake City, UT, 84115 (801) 524-5287.

6. Air Methods Database. Available on the Cleanup Information electronic bulletin board (CLU-IN), formerly OSWER BBS. For further information, call (301) 589-8366. Communications: No Parity, 8 Databits, 1 Stopbit, F Duplex.

7. *Removal Program Representative Sampling Guidance: Air* (U.S. EPA, draft, expected Summer 1992).

8. *Respiratory Decision Logic* (NIOSH, 1987, Publication 87-108).

CHAPTER 7 MEDICAL SURVEILLANCE PROGRAM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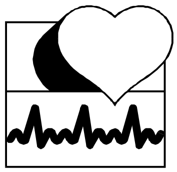
CHAPTER 7 MEDICAL SURVEILLANCE PROGRAM

7.0 INTRODUCTION



Workers engaged in hazardous waste operations and emergency response activities perform tasks that may expose them to a number of potential hazards, including: toxic chemicals; safety and biological hazards; and physical agents, such as heat stress and radiation. A medical program is essential for assessing and monitoring employee health, both prior to placement and during the course of work; for providing emergency and other treatment, as needed; and for keeping accurate records for future reference. A comprehensive medical surveillance program is required by §1910.120(f) of HAZWOPER. The standards contain provisions for baseline, periodic, and termination medical examinations.

The goal of a medical surveillance program, and of appropriate screening and monitoring in the workplace, is the protection of employees' health. Two factors are critical for achieving this goal:

- Detecting pre-existing disease or medical conditions that may place an employee performing certain tasks at an increased risk; and
- Minimizing individual exposures at the workplace, so that the disease process is never initiated.

Helping to place and maintain employees in work that is commensurate with their capabilities and, whenever possible, attempting to avoid certain exposure situations, will help achieve this goal of disease prevention.

An employer should develop a comprehensive medical program based on the specific needs, location, and potential exposures of its employees. The program should be designed by an experienced occupational health physician or other qualified occupational health consultant in conjunction with the employer's occupational health and safety professional. All occupational medical monitoring examinations and procedures should be performed by or under the direction of a physician who is board-certified in occupational medicine or a medical doctor who has had extensive experience managing occupational health services.

7.1 EMPLOYEES COVERED BY THE SURVEILLANCE PROGRAM

A medical surveillance program must include monitoring for four groups of employees:

- Employees who are, or may be, exposed to PELs of hazardous substances or health hazards for 30 or more days per year;
- Employees who wear a respirator for 30 or more days per year;
- Members of organized HAZMAT teams; and
- Employees who are injured as a result of overexposure during a site emergency, or who show symptoms of illness that may have resulted from exposure to hazardous substances.

OSHA standards represent only the minimum that is required by law and in no way preclude anyone from taking additional actions to ensure the well-being of their employees. For example, the medical surveillance policy for EPA employees (as outlined in the *OSWER Integrated Health and Safety Program Standard Operating Practice*) is more restrictive than the OSHA standards, and requires monitoring for employees who are potentially exposed to hazardous substances for 20 or more days per year.

7.2 FREQUENCY AND CONTENT OF MEDICAL EXAMINATIONS

All employees who are required by HAZWOPER to participate in a medical surveillance program must undergo a baseline medical examination prior to a field assignment. After this initial examination, employees must have a follow-up medical exam at least once per year, unless an attending physician believes a longer interval is appropriate. This longer interval, however, cannot exceed 2 years.

If the attending physician believes it is necessary by virtue of the nature of employees' potential exposure, more frequent medical examinations may be required. Irrespective of whether a baseline exam was performed, employees must also receive a medical examination as soon as possible if:

- The employee is injured or becomes ill from exposure to hazardous substances on-site; or

- The employee develops signs or symptoms indicative of possible overexposure to hazardous substances.

All potentially exposed employees must be trained to recognize symptoms that might be indicative of overexposure to chemicals or physical agents such as heat stress. These could include dizziness, rashes, shortness of breath, numbness, and fatigue.

In addition, employees who are reassigned or who terminate employment must receive a final examination. This examination is only required if the employee has not had an examination within the past 6 months. All required medical examinations must be provided without cost to the employee, without loss of pay, and at a reasonable time and place.

The content of medical examinations should be determined by the attending physician and the site Health and Safety Officer, but certain key elements must be included. The physician must complete a medical and work history with emphasis on the symptoms related to handling hazardous substances. Further, the physician must determine the employee's fitness for the types of duties to be assigned, including whether the employee needs to wear personal protective equipment based on the anticipated conditions at the work site.

To ensure that the physician understands the OSHA and EPA medical surveillance requirements, the employer must provide a copy of the standard and its appendices to the physician. Substance-specific standards (e.g., for lead and asbestos) should also be provided, if appropriate. The employer is also responsible for describing to the physician each employee's duties relative to potential exposure levels. Additionally, the physician must be provided with information from the employee's previous medical exams and a complete description of the types of PPE that the employee will be expected to wear. This information is required so that the physician can adequately assess the employee's capacity to wear PPE and other required equipment.

Once an exam has been completed, the physician must submit a written opinion to the employer who then has the responsibility to provide that opinion to the employee. The opinion must contain:

- The results of the medical examination and tests;
- Any recommended work limitations; and
- The physician's opinion concerning the medical condition of the employee, including any conditions that need further examination and treatment, or that would place the employee at an increased risk of injury from respirator use or work in a hazardous substance environment.

Exhibit 7-1 outlines a recommended medical program with screening and examination protocols. These recommendations are based on known health risks for hazardous waste site personnel, a review of available data on their exposures, and an assessment of several established medical programs. Because conditions and hazards vary considerably at each site, only general guidelines are provided here.

7.2.1 Baseline Screening

Pre-placement or baseline screening has two major functions: (1) to determine an individual's fitness for duty, including the ability to work while wearing protective equipment; and (2) to provide baseline data for comparison with future medical data. To ensure that prospective employees are able to meet work requirements, the pre-placement screening should focus on the following areas:

<u>Occupational and Medical History</u>

- Require all personnel to fill out an occupational and medical history questionnaire, describing all prior occupational exposures to chemical and physical hazards.
- Take note of past illnesses and chronic diseases, particularly atopic diseases such as eczema and asthma, lung diseases, and cardiovascular disease.
- Review symptoms, especially shortness of breath or labored breathing on exertion, other chronic respiratory symptoms, chest pain, high blood pressure, heat intolerance, or sensitivity to particular substances.
- Record relevant lifestyle habits (e.g., smoking, alcohol/drug use) and hobbies.

<u>Physical Examination</u>

- Conduct a comprehensive physical examination focusing on the pulmonary, cardiovascular, and musculoskeletal systems.

EXHIBIT 7-1
Minimum Examination Types and Protocols

Examination Type	Baseline	Periodic	Termination	Unscheduled
History and Physical Exam				
Complete Medical History	X		X	X
Interval History		X		
Physical Examination by Physician	X	X	X	X
Visual Acuity	X	X	X	O
Routine Laboratory Tests/Procedures				
Pulmonary Function	X	X	X	O
Audiometry	X	X	X	O
Electrocardiogram	X	O	X	O
Chest X-ray*	X	O	X	O
Complete Blood Count	X	X	X	O
Routine Urinalysis	X	X	X	O
Blood Chemistry	X	X	X	O
Special Tests**				
Cholinesterase	X	O	O	O
Methemoglobin	O	O	O	O
Heavy Metal Screen	X	O	O	O
Urine and Sputum Cytology	O	O	O	O
Polychlorinated Biphenyl (PCB)	O	O	O	O
Cardiovascular Stress Test	X	O	-	-

X Recommended
O As indicated

* Chest X-rays not repeated more than once per year.

** Any special test which may be considered on a periodic basic should be included in the baseline test.

Source: *Occupational Medical Monitoring Program Guidelines for SARA Hazardous Waste Field Activity Personnel* (U.S. EPA, 1990, Publication 9285.3-04).

- Note conditions that could increase susceptibility to heat stroke or that could affect respirator use.

Ability to Work While Wearing PPE

- Disqualify individuals who are unable to perform based on the medical history and physical exam (e.g., those with severe lung disease, heart disease, or back or orthopedic problems).
- Note limitations concerning the worker's ability to use PPE.
- Provide additional testing for ability to wear PPE where necessary.
- Complete a written assessment of worker's capacity to perform while wear a respirator, if wearing a respirator is a job requirement. Note that the OSHA respirator standard (29 CFR §1910.134) states that no employee should be assigned to a task that requires the use of a respirator unless that person is physically able to perform under such conditions.

Pre-placement screening can be used to establish baseline data to verify the efficacy of protective measures and to determine whether exposures have adversely affected the worker. Baseline testing may include both medical screening tests and biologic monitoring tests. Given the problem in predicting significant exposures for these workers, there are no clear guidelines for prescribing specific tests.

7.2.2 Periodic Medical Examinations

Periodic medical examinations should be developed and used in conjunction with pre-placement screening examinations. Comparison of sequential medical reports with baseline data is essential for determining biologic trends that may mark early signs of adverse health effects, and thereby facilitate appropriate protective measures.

The frequency and content of examinations will vary, depending on the nature of the work and exposures. It is recommended that medical exam-inations be conducted at least annually; however, more frequent examinations may be necessary depending on the extent of potential or actual exposure, the type of chemicals involved, the duration of the work assignment, and the individual worker's profile. Periodic screening exams can include:

- Interval medical history, focusing on changes in health status, illnesses, and possible work-related symptoms;
- Physical examination; and
- Additional medical testing, depending on available exposure information, medical history, and examination results. Testing specific to possible medical effects of the worker's exposure can include pulmonary function tests, audiometric tests, vision tests, and blood and urine tests.

7.2.3 Termination Examination

At the end of employment as a hazardous waste site worker, all personnel should have a termination medical examination. A full examination is necessary at the termination of employment if any of the following criteria are not met:

- The last full medical examination was within the last 6 months;
- No exposure occurred since the last examination; and
- No symptoms associated with exposure occurred since the last examination.

7.3 EMERGENCY TREATMENT

Provisions for emergency treatment and acute non-emergency treatment should be made at each site. When developing plans, procedures, and equipment lists, the range of actual and potential hazards specific to the site should be considered, including chemical, physical, and biological hazards. Contractors, visitors, and other personnel may require emergency treatment in addition to site workers.

Emergency medical treatment should be integrated into the overall site emergency response program. **Exhibit 7-2** lists the recommended guidelines for establishing an emergency treatment program. Depending on the site's location and potential hazards, it may be important to identify additional medical facilities capable of sophisticated response to chemical or other exposures.

Non-emergency medical care should be arranged for hazardous waste site personnel who are experiencing health effects resulting from an exposure to hazardous substances. In conjunction with the medical surveillance program, off-site medical care should ensure that any potential job-related symptoms or illnesses are evaluated in the context of the employee's exposure. Off-site medical personnel should also investigate and treat non-job-related illnesses that may put the employee at risk because of task requirements.

7.4 CHEMICAL CONTAMINATION

Employees at hazardous waste sites may be exposed to a number of toxic chemicals with dangerous properties. Most sites contain a variety of chemical substances in gaseous, liquid, or solid forms that can enter the unprotected body. **Exhibit 7-3** lists some common chemicals found at hazardous waste sites, their potential health effects, and recommended medical procedures for monitoring employee exposure.

Preventing exposure to toxic chemicals is a primary concern at any site. Protective clothing and respirators help prevent the wearer from contamination, and good work practices and engineering controls help reduce contamination on protective clothing, instruments, and equipment However, contamination can occur even with these safeguards. It is important to identify the chemical hazards that exist at a site, and to take steps to prevent contamination.

EXHIBIT 7-2
Recommended Guidelines for Establishing an Emergency Treatment Program

- ✓ Train a team of site personnel in emergency first aid, including CPR and training that emphasizes treatment for explosion and burn injuries, heat stress, and acute chemical toxicity. This team should include an emergency medical technician if possible.
- ✓ Train personnel in emergency decontamination procedures in coordination with the Emergency Response Plan (see **Chapter 9**).
- ✓ Predesignate roles and responsibilities to be assumed by personnel in an emergency.
- ✓ Establish an emergency/first-aid station on-site, capable of providing stabilization for patients requiring off-site treatment and general first aid.
- ✓ Arrange for a physician who can be paged on a 24-hour basis.
- ✓ Set up an on-call team of medical specialists for emergency consultations (e.g., a toxicologist, dermatologist, hematologist, allergist, ophthalmologist, cardiologist, and neurologist).
- ✓ Establish a protocol for monitoring heat stress.
- ✓ Make plans in advance for emergency transportation to and contamination control procedures for treatment at a nearby medical facility.
- ✓ Post names, phone numbers, addresses, and procedures for contacting on-call physicians, medical specialists, ambulance services, medical facilities, emergency, fire, and police services, and poison control hotline.
- ✓ Provide maps and directions to medical facilities, and confirm that all managers and individuals involved in medical response know the location of the nearest emergency medical facility.
- ✓ Establish a radio-communication system for emergency use.
- ✓ Review emergency procedures daily with site personnel at safety meetings before beginning work shifts.

EXHIBIT 7-3
Common Chemical Toxicants Found at Hazardous Waste Sites, their Health Effects, and Medical Monitoring

HAZARDOUS SUBSTANCE OR CHEMICAL GROUP	COMPOUNDS	USES	TARGET ORGANS	POTENTIAL HEALTH EFFECTS	MEDICAL MONITORING
Aromatic Hydrocarbons	Benzene Ethyl benzene Toluene Xylene	Commercial solvents and intermediates for synthesis in the chemical and pharmaceutical industries.	Blood Bone marrow CNS[a] Eyes Respiratory system Skin Liver Kidney	All cause: CNS[b] depression: decreased alertness, headache, sleepiness, loss of consciousness. Defatting dermatitis. Benzene suppresses bone-marrow function, causing blood changes. Chronic exposure can cause leukemia. Note: Because other aromatic hydrocarbons may be contaminated with benzene during distillation, benzene-related health effects should be considered when exposure to any of these agents is suspected.	Occupational/general medical history emphasizing prior exposure to these or other toxic agents. Medical examination with focus on liver, kidney, nervous system, and skin. Laboratory testing: CBC[b] Platelet count Measurement of kidney and liver function.
Asbestos (or asbestiform particles)		A variety of industrial uses, including: Building Construction Cement work Insulation Fireproofing Pipes and ducts for water, air, and chemicals Automobile brake pads and linings	Lungs Gastrointestinal system	Chronic effects: Lung cancer Mesothelioma Asbestosis Gastrointestinal malignancies Asbestos exposure coupled with cigarette smoking has been shown to have a synergistic effect in the development of lung cancer.	History and physical examination should focus on the lungs and gastrointestinal system. Laboratory tests should include a stool test for occult blood evaluation as a check for possible hidden gastrointestinal malignancy. A high quality chest X-ray and pulmonary function test may help to identify long-term changes associated with asbestos diseases; however, early identification of low-dose exposure is unlikely.
Dioxin (see Herbicides)					

[a] CNS = Central nervous system.
[b] CBC = Complete blood count.

HAZARDOUS SUBSTANCE OR CHEMICAL GROUP	COMPOUNDS	USES	TARGET ORGANS	POTENTIAL HEALTH EFFECTS	MEDICAL MONITORING
Halogenated Aliphatic Hydrocarbons	**Carbon tetrachloride** **Chloroform** **Ethyl bromide** **Ethyl chloride** **Ethylene dibromide** **Ethylene dichloride** **Methyl chloride** **Methyl chloroform** **Methylene chloride** **Tetrachloroethane** **Tetrachloroethylene (perchloroethylene)** **Trichloroethylene** **Vinyl chloride**	**Commercial solvents and intermediates in organic synthesis.**	**CNS[a]** **Kidney** **Liver** **Skin**	**All cause:** **CNS[a] depression: decreased alertness, headaches, sleepiness, loss of consciousness.** **Kidney changes: decreased urine flow, swelling (especially around eyes), anemia.** **Liver changes: fatigue, malaise, dark urine, liver enlargement, jaundice.** **Vinyl chloride is a known carcinogen; several others in this group are potential carcinogens.**	**Occupational/general medical history emphasizing prior exposure to these or other toxic agents.** **Medical examination with focus on liver, kidney, nervous system, and skin.** **Laboratory testing for liver and kidney function; carboxyhemoglobin where relevant.**
Heavy Metals	**Arsenic** **Beryllium** **Cadmium** **Chromium** **Lead** **Mercury**	**Wide variety of industrial and commercial uses.**	**Multiple organs and systems including:** **Blood** **Cardiopulmonary** **Gastrointestinal** **Kidney** **Liver** **Lung** **CNS[a]** **Skin**	**All are toxic to the kidneys.** **Each heavy metal has its own characteristic symptom cluster. For example, lead causes decreased mental ability, weakness (especially in hands), headache, abdominal cramps, diarrhea, and anemia. Lead can also affect the blood-forming mechanism, kidneys, and the peripheral nervous system.** **Long-term effects[c] also vary. Lead toxicity can cause permanent kidney and brain damage; cadmium can cause kidney or lung disease. Chromium, beryllium, arsenic, and cadmium have been implicated as human carcinogens.**	**History-taking and physical exam: search for symptom clusters associated with specific metal exposure, e.g., for lead look for neurological deficit, anemia, and gastrointestinal symptoms.** **Laboratory testing:** **Measurements of metallic content in blood, urine, and tissues (e.g., blood lead level; urine screen for arsenic, mercury, chromium, and cadmium).** **CBC[b]** **Measurement of kidney function, and liver function where relevant.** **Chest X-ray or pulmonary function testing where relevant.**

[c] Long-term effects generally manifest in 10 to 30 years.

HAZARDOUS SUBSTANCE OR CHEMICAL GROUP	COMPOUNDS	USES	TARGET ORGANS	POTENTIAL HEALTH EFFECTS	MEDICAL MONITORING
Herbicides	**Chlorophenoxy compounds:** **2,4-dichloro-phenosyacetic acid (2,4-D)** **2,4,5-trichloro-phenoxyacetic acid (2,4,5-T)** **Dioxin (tetrachloro-dibenzo-p-dioxin, TCDD), which occurs as a trace contaminant in these compounds, poses the most serious health risk.**	**Vegetation control.**	**Kidney** **Liver** **CNS**[a] **Skin**	**Chlorophenoxy compounds can cause chloracne, weakness or numbness of the arms and legs, and may result in long-term nerve damage.** **Dioxin causes chloracne and may aggravate pre-existing liver and kidney diseases.**	**History and physical exam should focus on the skin and nervous system.** **Laboratory tests include:** **Measurement of liver and kidney function, where relevant.** **Urinalysis.**

HAZARDOUS SUBSTANCE OR CHEMICAL GROUP	COMPOUNDS	USES	TARGET ORGANS	POTENTIAL HEALTH EFFECTS	MEDICAL MONITORING
Organochlorine Insecticides	**Chlorinated ethanes:** **DDT** **Cyclodienes:** **Aldrin** **Chlordane** **Dieldrin** **Endrin** **Chlorocyclohexanes:** **Lindane**	**Pest control.**	**Kidney** **Liver** **CNS**[a]	**All cause acute symptoms of apprehension, irritability, dizziness, disturbed equilibrium, tremor, and convulsions.** **Cyclodienes may cause convulsions without any other initial symptoms.** **Chlorocyclohexanes can cause anemia. Cyclodienes and chlorocyclohexanes cause liver toxicity and can cause permanent kidney damage.**	**History and physical exam should focus on the nervous system.** **Laboratory tests include:** **Measurement of kidney and liver function.**

EXHIBIT 7-3 (cont'd)

HAZARDOUS SUBSTANCE OR CHEMICAL GROUP	COMPOUNDS	USES	TARGET ORGANS	POTENTIAL HEALTH EFFECTS	MEDICAL MONITORING
Organophosphate and Carbamate Insecticides	Organophosphate: Diazinon Dichlorovos Dimethoate Trichlorfon Malathion Methyl parathion Parathion Carbamate: Aldicarb Baygon Zectran	Pest control.	CNS[a] Liver Kidney	All cause a chain of internal reactions leading to neuromuscular blockage. Depending on the extent of poisoning, acute symptoms range from headaches, fatigue, dizziness, increased salivation and crying, profuse sweating, nausea, vomiting, cramps, and diarrhea to tightness in the chest, muscle twitching, and slowing of the heartbeat. Severe cases may result in rapid onset of unconsciousness and seizures. A delayed effect may be weakness and numbness in the feet and hands. Long-term, permanent nerve damage is possible.	Physical exam should focus on the nervous system. Laboratory tests should include: RBC[d] cholinesterase levels for recent exposure (plasma cholinesterase for acute exposures). Measurement of delayed neurotoxicity and other effects.
Polychlorinated Biphenyls (PCBs)		Wide variety of industrial uses.	Liver CNS[a] (speculative) Respiratory system (speculative) Skin	Various skin ailments, including chloracne; may cause liver toxicity; carcinogenic to animals.	Physical exam should focus on the skin and liver. Laboratory tests include: Serum PCB levels. Triglycerides and cholesterol. Measurement of liver function.

[d] RBC = Red blood count.

Chemical exposures are generally divided into two categories: acute and chronic. Symptoms resulting from acute exposures usually occur during and shortly after exposure to a high concentration of a contaminants. A chronic exposure usually occurs at a low concentration over a long period of time. Lethal concentrations vary with each chemical. The symptoms of an acute exposure for a given contaminant may be completely different from those resulting from a chronic exposure to the same contaminant. .

For chronic and acute exposures, the toxic effect may be temporary and reversible or permanent (causing disability or death). Although some chemicals cause obvious symptoms (e.g., burning, nausea, rashes), others may causes health damage without any warning signs (e.g., cancer, respiratory disease). Some toxic chemicals may be colorless and/or odorless, may dull the sense of smell, or may not produce immediate or obvious physiological sensation. A worker's senses or feelings cannot be relied upon in all cases to warn of toxic exposures. **Exhibit 7-4** lists the signs and warning symptoms of potential chemical exposure.

The primary routes of chemical contamination are as follows:

<u>Inhalation</u> is an exposure route of concern because the lungs are extremely vulnerable to chemical agents. Respiratory protection should be used if there is any possibility that the site may contain hazardous substances that can be inhaled. Chemicals can also enter the respiratory tract through punctured eardrums.

<u>Direct contact</u> of the skin and eyes is another route of exposure to hazardous substances. Some chemicals will directly injure the skin; some may pass through the skin into the bloodstream where they are transported to vulnerable organs. This absorption is enhanced by abrasions, cuts, heat, and moisture. Workers can protect against direct contact of a hazardous chemical by wearing PPE, refraining from use of contact lenses in contam-inated atmospheres, keeping hands away from the face, and minimizing contact with liquid and solid chemicals.

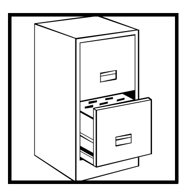
<u>Ingestion</u> occurs when chemicals are accidentally swallowed.

<u>Injection</u> can occur when chemicals are introduced into the body through puncture wounds, such as those caused by stepping or tripping or falling onto contaminated sharp objects. To protect against this type of exposure, the site should be prepared, and workers should wear safety shoes, avoid physical hazards, and take common sense precautions.

EXHIBIT 7-4
Signs and Symptoms of Chemical Contamination

- Behavioral changes
- Breathing difficulties
- Changes in complexion or skin color
- Coordination difficulties
- Coughing
- Dizziness
- Drooling, pupillary response
- Diarrhea
- Fatigue and/or weakness
- Irritability
- Irritation of eyes, nose, respiratory tract, skin or throat
- Headache
- Light-headedness
- Nausea
- Sneezing
- Sweating
- Tearing
- Blurred vision
- Cramps
- Tightness in the chest

7.5 MEDICAL RECORDS AND PROGRAM REVIEW



Medical records for employees must be maintained for at least 30 years after employment is terminated. These records must include the name and social security number of the employee, the physician's written opinions including recommended occupational limitations and results of examinations and tests, any employee medical complaints related to occupational hazardous substance exposure, and a copy of the material that the attending physician was provided before the examination. The employer is responsible for retaining the records if the employee or physician leaves the area, or if the company moves, is acquired, or goes out of business. In addition, employers who maintain 11 or more employees must keep injury and illness records for each establishment. Employers are also required to provide access to these records upon request by the employee or designated representative.

The medical surveillance program must be evaluated regularly to ensure its effectiveness. Maintenance and review of medical records and test results aid in assessing the effectiveness of the health and safety program.At a minimum, the Corporate Health and Safety Officer should perform the following record keeping activities annually:

- Ensure that each accident or illness was promptly investigated to determine the cause and make necessary changes in health and safety procedures;
- Evaluate specific medical testing to determine potential site exposures;
- Add or delete medical tests as suggested by current industrial hygiene and environmental data;
- Review potential exposures and the HASP at all sites to determine whether additional testing is required; and
- Review emergency treatment procedures and update lists of emergency contacts.
- Assure timely access upon employee request.

FURTHER GUIDANCE: For more information on developing a medical surveillance program, see:

1. *NIOSH Pocket Guide to Chemical Hazards* (NIOSH, 1991, Publication 90-117).
2. *Occupational Medical Monitoring Program Guidelines for SARA Hazardous Waste Field Activity Personnel* (U.S. EPA, 1990, Publication 9285.3-04).
3. *Occupational Safety and Health Guidelines for Chemical Hazards/Supplement II-OHG* (NIOSH, 1989, Publication 89-104).