5. Medical Program

Contents

Introduction

Workers handling hazardous wastes can experience high levels of stress. Their daily tasks may expose them to toxic chemicals, safety hazards, biologic hazards, and radiation. They may develop heat stress while wearing protective equipment or working under temperature extremes, or face life-threatening emergencies such as explosions and fires. Therefore, a medical program is essential to assess and monitor workers' health and fitness both prior to employment and during the course of work; to provide emergency and other treatment as needed; and to keep accurate records for future reference. In addition, OSHA recommends a medical evaluation for employees required to wear a respirator (29 CFR Part 1910.134[b][10]), and certain OSHA standards include specific medical requirements (e.g., 29 CFR Part 1910.95 and 29 CFR Parts 1910.1001 through 1910.1045). Information from a site medical program may also be used to conduct future epidemiological studies; to adjudicate claims; to provide evidence in litigation; and to report workers' medical conditions to federal, state, and local agencies, as required by law.

This chapter presents general guidelines for designing a medical program for personnel at hazardous waste sites. It includes information and sample protocols for pre-employment screening and periodic medical examinations, guidelines for emergency and non-emergency treatment, and recommendations for program record-keeping and review. In addition, it supplies a table of some common chemical toxicants found at hazardous waste sites with recommended medical monitoring procedures.

The recommendations in this chapter assume that workers will have adequate protection from exposures through administrative and engineering controls, and appropriate personal protective equipment and decontamination procedures, as described elsewhere in this manual. Medical surveillance should be used to complement other controls.

Developing a Program

A medical program should be developed for each site based on the specific needs, location, and potential exposures of employees at the site. The program should be designed by an experienced occupational health physician or other qualified occupational health consultant in conjunction with the Site Safety Officer. The director of a site medical program should be a physician who is board-certified in occupational medicine or a medical doctor who has had extensive experience managing occupational health services. A director and/or examining physician with such qualifications may be difficult to find, due to the shortage of doctors trained in occupational medicine in remote geographic areas where many hazardous waste sites are located. If an occupational health physician is not available, the site medical program may be managed, and relevant examinations performed, by a local physician with assistance from an occupational medicine consultant. These functions may also be performed by a qualified Registered Nurse, preferably an Occupational Health Nurse, under the direction of a suitably qualified physician who has responsibility for the program.[1]

All medical test analyses should be performed by a laboratory that has demonstrated satisfactory performance in an established inter-laboratory testing program [1]. The clinical or diagnostic laboratory to which samples are sent should meet either (1) minimum requirements under the Clinical Laboratories Improvement Act of 1967 (42 CFR Part 74 Subpart M Section 263[a]), or (2) the conditions for coverage under Medicare. These programs are administered by the Health Care Financing Administration (HCFA), U.S. Department of Health and Human Services (DHHS).

A site medical program should provide the following components:

- Surveillance:
  - Pre-employment screening.
  - Periodic medical examinations (and follow-up examinations when appropriate).
  - Termination examination.
- Treatment:
  - Emergency
  - Non-emergency (on a case-by-case basis)
- Record-keeping.
- Program review.

Table 5-1 outlines a recommended medical program; screening and examination protocols are described in the following sections. These recommendations are based on known health risks for hazardous waste workers, 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 given.

The effectiveness of a medical program depends on active worker involvement. In addition, management should have a firm commitment to worker health and safety, and is encouraged to express this commitment not only by medical surveillance and treatment, but also through management directives and informal encouragement of employees to maintain good health through exercise, proper diet, and avoidance of tobacco, alcohol abuse and drug abuse. In particular, management should:

- Urge prospective employees to provide a complete and detailed occupational and medical history.

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[1] Certified, state-licensed (where required) Physician's Assistants may also perform these examinations if a physician is available on the premises.

- Assure employees of confidentiality.
- Require workers to report any suspected exposures, regardless of degree.
- Require workers to bring any unusual physical or psychological conditions to the physician's attention. Employee training should emphasize that vague disturbances or apparently minor complaints (such as skin irritation or headaches) may be important.

When developing an individual program, site conditions must be considered and the monitoring needs of each worker should be determined based on the worker's medical and occupational history, as well as current and potential exposures on site. The routine job tasks of each worker should be considered. For instance, a heavy equipment operator exposed to significant noise levels would require a different monitoring protocol from a field sample collector with minimal noise exposure. Likewise, an administrator may only need a pre-employment screening for ability to wear personal protective equipment-if this is an occasional requirement-rather than a more comprehensive program.

The potential exposures that may occur at a site must also be considered. While it is often impossible to identify every toxic substance that exists at each hazardous waste site, certain types of hazardous substances or chemicals are more likely to be present than others. Some of these are:

- Aromatic hydrocarbons.
- Asbestos (or asbestiform particles).
- Dioxin.
- Halogenated aliphatic hydrocarbons.
- Heavy metals.
- Herbicides.
- Organochlorine insecticides.
- Organophosphate and carbamate insecticides.
- Polychlorinated biphenyls (PCBs).

Table 5-2 lists these groups, with representative compounds, uses, health effects, and available medical monitoring procedures.

In compiling a testing protocol, bear in mind that standard occupational medical tests were developed in factories and other enclosed industrial environments, and were based on the presence of specific identifiable toxic chemicals and the possibility of a significant degree of exposure. Some of these tests may not be totally appropriate for hazardous waste sites, since available data suggest that site workers have low-level exposures to many chemicals concurrently, plus brief high-level exposure to some chemicals [2]. In addition, most testing recommendations, even those for specific toxic substances, have not been critically evaluated for efficacy.

Another important factor to consider is that risk can vary, not only with the type, amount and duration of exposure, but also with individual factors such as age, sex, weight, stress, diet, susceptibility to allergic-type reactions, medications taken, and offsite exposures (e.g., in hobbies such as furniture refinishing and automotive body work).

Table 5-1. Recommended Medical Program

COMPONENT	RECOMMENDED	OPTIONAL
Pre-Employment Screening	• Medical history. • Occupational history. • Physical examination. • Determination of fitness to work wearing protective equipment. • Baseline monitoring for specific exposures.	• Freezing pre-employment serum specimen for later testing (limited to specific situations, see Baseline Date for Future Exposures in this chapter).
Periodic Medical Examinations	• Yearly update of medical and occupational history; yearly physical examination; testing based on (1) examination results, (2) exposures, and (3) job class and task. • More frequent testing based on specific exposures.	• Yearly testing with routine medical tests.
Emergency Treatment	• Provide emergency first aid on site. • Develop liaison with local hospital and medical specialists. • Arrange for decontamination of victims. • Arrange in advance for transport of victims. • Transfer medical records; give details of incident and medical history to next care provider.	
Non-emergency Treatment	• Development mechanism for non-emergency health care.	
Recordkeeping and Review	• Maintain and provide access to medical records in accordance with OSHA and state regulations. • Report and record occupational injuries and illnesses. • Review Site Safety Plan regularly to determine if additional testing is needed. • Review program periodically. Focus on current site hazards, exposures, and industrial hygiene standards.	

Table 5-2. 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[a] 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 gastrointest-inal malignancy. A high quality chest X-ray and pulmonary function test may help to identify long-term changes associated with asbestos diseases; however, early ident-ification of low-dose exposure is unlikely.
Dioxin (see Herbicides)					

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 Tetrachloro-ethane Tetrachloro-ethylene (perchloro-ethylene) Trichloro-ethylene 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 the eyes), anemia Liver changes: fatigue, malaise, dark urine, liver enlarge-ment, 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; carboxy-hemoglobin where relevant.
Heavy Metals	Arsenic Beryllium Cadmium Chromium Lead Mercury	Wide variety of industrial and commercial users.	Multiple organs and systems including: Blood Cardiopul-monary Gastrointe s-tinal 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 hands), headache, abdominal cramps, diarrhea, and anemia. Lead can also affect the bloodforming 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 exposures, e.g., for lead look for neuro-logical deficit, anemia, and gastro-intestinal symptoms. Laboratory testing: Measurement of metallic content in blood, urine, and tissues (e.g., blood lead level; urine screen for arsenic, mercury, chrom-ium, and cadmium). CBC[b] Measurement of kidney function, and liver function where relevant. Chest X-ray or pulmonary function testing where relevant.

HAZARDOUS SUBSTANCE OR CHEMICAL GROUP	COMPOUNDS	USES	TARGET ORGANS	POTENTIAL HEALTH EFFECTS	MEDICAL MONITORING
Herbicides	Chlorophenoxy compounds: 2,4-dichloro-phenoxyacetic acid (2,4-D) 2,4,5-trichloro-phenoxyacetic acid (2,4,5-T) Dioxin (tetrachloro-dibenzo-p-dioxin, TCDD), which occurs at 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.
Organochlorine Insecticides	Chlorinated ethanes: DDT Cyclodienes: Aldrin Chlordane Dieldrin Endrin Chlorocyclo-hexanes: Lindane	Pest control.	Kidney Liver CNS[a]	All cause acute symptoms of apprehen-sion, irritability, dizzi-ness, disturbed equili-brium, tremor, and convulsions. Cyclodienes may cause convulsions without any other initial symptoms. Chlorocyclohexanes can cause anemia. Cyclo-dienes and chlorocyclo-hexanes 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. CBC[b] for exposure to chlorocyclo-hexanes.

HAZARDOUS SUBSTANCE OR CHEMICAL GROUP	COMPOUNDS	USES	TARGET ORGANS	POTENTIAL HEALTH EFFECTS	MEDICAL MONITORING
Organo-phosphate and Carbamate Insecticides	Organophosphate: Diazinon Dichclorovos 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 block-age. 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] cholinest-erase levels for recent exposure (plasma cholinest-erase for acute exposures). Measurement of delayed neuro-toxicity and other effects.
Polychlorinated Biphenyls (PCBs)		Wide variety of industrial uses.	Liver CNS[a] (specula-tive) Respiratory system (specula-tive) 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.

[a]CNS = Central nervous system
[b]CBC = Complete blood count.
[c]Long-term effects generally manifest in 10 to 30 years.
[d]RBC=Red blood count.

Pre-employment Screening

Pre-employment screening has two major functions: (1) determination of an individual's fitness for duty, including the ability to work while wearing protective equipment, and (2) provision of baseline data for comparison with future medical data. These functions are discussed below. In addition, a sample pre-employment examination is described.

Determination of Fitness for Duty

Workers at hazardous waste sites are often required to perform strenuous tasks (e.g., moving 55-gallon drums) and wear personal protective equipment, such as respirators and protective clothing, that may cause heat stress and other problems (see Chapter 8 for details). To ensure that prospective employees are able to meet work requirements, the pre-employment screening should focus on the following areas:

Occupational and Medical History

- Make sure the worker fills out an occupational and medical history questionnaire. Review the questionnaire before seeing the worker. In the examining room, discuss the questionnaire with the worker, paying special attention to prior occupational exposures to chemical and physical hazards.
- Review 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, and heat intolerance.
- Identify individuals who are vulnerable to particular substances (e.g., someone with a history of severe asthmatic reaction to a specific chemical).
- Record relevant lifestyle habits (e.g., cigarette smoking, alcohol and drug use) and hobbies.

Physical Examination

- Conduct a comprehensive physical examination of all body organs, focussing on the pulmonary, cardiovascular, and musculoskeletal systems.
- Note conditions that could increase susceptibility to heat stroke, such as obesity and lack of physical exercise.
- Note conditions that could affect respirator use, such as missing or arthritic fingers, facial scars, dentures, poor eyesight, or perforated ear drums.

Ability to Work While Wearing Protective Equipment [3]

- Disqualify individuals who are clearly 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 protective equipment (e.g., individuals who must wear contact lenses cannot wear full-face piece respirators).
- Provide additional testing (e.g., chest X-ray, pulmonary function testing, electrocardiogram) for ability to wear protective equipment where necessary.
- Base the determination on the individual worker's profile (e.g., medical history and physical exam, age, previous exposures and testing).
- Make a written assessment of the worker's capacity to perform while wearing a respirator, if wearing a respirator is a job requirement. Note that the Occupational Safety and Health Administration (OSHA) respirator standard (29 CFR Part 1910.134) states that no employee should be assigned to a task that requires the use of a respirator unless it has been determined that the person is physically able to perform under such conditions.

Baseline Data for Future Exposures

Pre-employment screening can be used to establish baseline data to subsequently verify the efficacy of protective assures and to later determine if exposures have adversely affected the worker. Baseline testing may include both medical screening tests and biologic monitoring tests. The latter (e.g., blood lead level) may be useful for ascertaining pre-exposure levels of specific substances to which the worker may be exposed and for which reliable tests are available. Given the problem in predicting significant

exposures for these workers, there are no clear guidelines for prescribing specific tests. The following approach identifies the types of tests that may indicated:

- A battery of tests based on the worker's past occupational and medical history and an assessment of significant potential exposures. See Table 5-3 for examples of tests frequently performed by occupational physicians.
- Standard established testing for specific toxicants in situations where workers may receive significant exposures to these agents. For example, long-term exposure during cleanup of a polychlorinated biphenyls (PCB) waste facility can be monitored with pre-employment and periodic serum PCB testing [4]. Standard procedures are available for determining levels of other substances, e.g., lead, cadmium, arsenic, and organophosphate pesticides.
- Where applicable, pre-employment blood specimens and serum frozen for later testing. (PCBs and some pesticides are examples of agents amenable to such monitoring.)

Table 5-3. Tests Frequently Performed by Occupational Physicians

FUNCTION	TEST	EXAMPLE
Liver:		
General	Blood tests	Total protein, albumin, globulin, total bilirubin (direct bilirubin if total is elevated).
Obstruction	Enzyme test	Alkaline phosphatase.
Cell injury	Enzyme tests	Gamma glutamyl transpeptidase (GGTP), lactic dehydrogenase (LDH), serum glutamic- Oxaloacetic transaminase (SGOT), serum glutamic-pyruvic transaminase (SGPT).
Kidney:		
General	Blood tests	Blood urea nitrogen (BUN), creatinine, uric acid.
Multiple Systems and Organs	Urinalysis	Including color; appearance; specific gravity; pH; qualitative glucose, protein, bile, and acetone; occult blood; microscopic examination of centrifuged sediment.
Blood-Forming Function	Blood tests	Complete blood count (CBC) with differential and platelet evaluation, including white cell count (WBC), red blood count (RBC), hemoglobin (HGB), hematocrit or packed cell volume (HCT), and desired erythrocyte indices. Reticulocyte count may be appropriate if there is a likelihood of exposure to hemolytic chemicals.

Sample Pre-Employment Examination

Occupational and Medical History

- Do a complete medical history emphasizing these systems: nervous, skin, lung, blood-forming, cardiovascular, gastrointestinal, genitourinary, reproductive, ear, nose, and throat.

Physical Examination

Include at least the following:

- Height, weight, temperature, pulse, respiration, and blood pressure.
- Head, nose, and throat.
- Eyes. Include vision tests that measure refraction, depth perception, and color vision. These tests should be administered by a qualified technician or physician. Vision quality is essential to safety, the accurate reading of instruments and labels, the avoidance of physical hazards, and for appropriate response to color-coded labels and signals.
- Ears. Include audiometric tests, performed at 500, l,000, 2,000, 3,000, 4,000, and 6,000 hertz (Hz) pure tone in an approved booth (see requirements listed in 29 CFR Part 1910.95, Appendix D). Tests should be administered by a qualified technician, and results read by a certified audiologist or a physician familiar with audiometric evaluation. The integrity of the eardrum should be established since perforated eardrums can provide a route of entry for chemicals into the body. The physician evaluating employees with perforated eardrums should consider the environmental conditions of the job and discuss possible specific safety controls with the Site Safety Officer, industrial hygienist, and/or other health professionals before deciding whether such individuals can safely work on site.
- Chest (heart and lungs).
- Peripheral vascular system.
- Abdomen and rectum (including hernia exam).
- Spine and other components of the musculoskeletal system.
- Genitourinary system.
- Skin.
- Nervous system.

Tests:

- Blood.
- Urine.
- A 14 x 17-inch posterior/anterior view chest X-ray, with lateral or oblique views only if indicated or if mandated by state regulations. The X-ray should be taken by a certified radiology technician and interpreted by a board-certified or board-eligible radiologist. Chest X-rays taken in the last 12-month period, as well as the oldest chest X-ray available, should be obtained and used for comparison. Chest X-rays should not be repeated more than once a year, unless otherwise determined by the examining physician.

Ability to Perform While Wearing Protective Equipment

To determine a worker's capacity to perform while wearing protective equipment, additional tests may be necessary, for example:

- **Pulmonary function testing.** Measurement should include forced expiratory volume in 1 second (FEV_1), forced vital capacity (FVC), and FEV_1-to-FVC ratio, with interpretation and comparison to, normal predicted values corrected for age, height, race, and sex. Other factors such as FEF, MEFR, MVV, FRC, RV, and TLC[1] may be included for additional information. A permanent record of flow curves should be placed in the worker's medical records. The tests should be conducted by a certified technician and the results interpreted by a physician.

[1] FEF = forced expiratory flow; MEFR = maximal expiratory flow rate; MVV = maximal voluntary ventilation; FRC = functional residual capacity; RV = residual volume; TLC = total lung capacity.

- **Electrocardiogram (EKG).** At least one standard, 12-lead resting EKG should be performed at the discretion of the physician. A "stress test" (graded exercise) may be administered at the discretion of the examining physician, particularly where heat stress may occur.

Baseline Monitoring

If there is likelihood of potential onsite exposure to a particular toxicant, specific baseline monitoring should be performed to establish data relating to that toxicant.

Periodic Medical Examinations

Periodic Screening

Periodic medical examinations should be developed and used in conjunction with pre-employment screening examinations. Comparison of sequential medical reports with baseline data is essential to determine 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. Generally, medical examinations have been recommended at least yearly. 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. For example, workers participating in the cleanup of a PCB-contaminated building were initially examined monthly for serum PCB levels. Review of the data from the first few months revealed no appreciable evidence of PCB exposure. The frequency of PCB testing was then reduced [4]. Periodic screening exams can include:

- Interval medical history, focusing on changes in health status, illnesses, and possible work-related symptoms. The examining physician should have information about the worker's interval exposure history, including exposure monitoring at the job site, supplemented by worker-reported exposure history and general information on possible exposures at previously worked sites.
- Physical examination.
- Additional medical testing, depending on available exposure information, medical history, and examination results. Testing should be specific for the possible medical effects of the worker's exposure. Multiple testing for a large range of potential exposures is not always useful; it may involve invasive procedures (e.g., tissue biopsy), be expensive, and may produce false-positive results.
  - *Pulmonary function tests* should be administered if the individual uses a respirator, has been or may be exposed to irritating or toxic substances, or if the individual has breathing difficulties, especially when wearing a respirator.
  - *Audiometric tests*. Annual retests are required for personnel subject to high noise exposures (an 8-hour, time-weighted average of 85 dBA[2] or more), those required to wear hearing protection, or as otherwise indicated.
  - *Vision tests*. Annual retests are recommended to check for vision degradation.
  - *Blood and urine tests* when indicated.

[2] dBA = decibels on A-weighted scale (29 CFR Part 1910.95).

Sample Periodic Medical Examination

The basic periodic medical examination is the same as the pre-employment screening (see previous section, *Sample Pre-Employment Examination*), modified according to current conditions, such as changes in the worker's symptoms, site hazards, or exposures.

Termination Examination

At the end of employment at a hazardous waste site, all personnel should have a medical examination as described in the previous sections (see *Sample Pre-Employment Examination*). This examination may be limited to obtaining an interval medical history of the period since the last full examination (consisting of medical history, physical examination, and laboratory tests) if all three following conditions are met:

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

If any of these criteria are not met, a full examination is medically necessary at the termination of employment.

Emergency Treatment

Provisions for emergency treatment and acute non-emergency treatment should be made at each site. Preplanning is vital.

When developing plans, procedures, and equipment lists, the range of actual and potential hazards specific to the site should be considered, including chemical, physical (such as heat and/or cold stress, falls and trips), and biologic hazards (animal bites and plant poisoning as well as hazardous biological wastes). Not only site workers, but also contractors, visitors, and other personnel (particularly firefighters) may require emergency treatment.

Emergency medical treatment should be integrated with the overall site emergency response program (see Chapter 12). The following are recommended guidelines for establishing an emergency treatment program.

- Train a team of site personnel in emergency first aid. This should include a Red Cross or equivalent certified course in cardiopulmonary resuscitation (CPR), and first-aid training that emphasizes treatment for explosion and burn injuries, heat stress, and acute chemical toxicity. In addition, this team should include an emergency medical technician (EMT) if possible. Table 5-4 lists signs and symptoms of exposure and heat stress that indicate potential medical emergencies.
- Train personnel in emergency decontamination procedures in coordination with the Emergency Response Plan (see Chapter 12 for details).
- Pre-designate roles and responsibilities to be assumed by personnel in an emergency.
- Establish an emergency/first-aid station on site, capable of providing (1) stabilization for patients requiring offsite treatment, and (2) general first aid (e.g., minor cuts, sprains, abrasions).
    - Locate the station in the clean area adjacent to the decontamination area to facilitate emergency decontamination.
    - Provide a standard first-aid kit or equivalent supplies, plus additional items such as emergency/deluge showers, stretchers, portable water, ice, emergency eyewash, decontamination solutions, and fire-extinguishing blankets.
    - Restock supplies and equipment immediately after each use and check them regularly.

- 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 (see Monitoring section of Chapter 8).
- Make plans in advance for emergency transportation to, treatment at, and contamination control procedures for a nearby medical facility.
  - Educate local emergency transport and hospital personnel about possible medical problems on site; types of hazards and their consequences; potential for exposure; scope and function of the site medical program.
  - Assist the hospital in developing procedures for site-related emergencies. This will help to protect hospital personnel and patients, and to minimize delays due to concerns about hospital safety or contamination.
  - For specific illnesses or injuries, provide details of the incident and the worker's past medical history to the appropriate hospital staff. This is especially crucial when specific medical treatment is required, e.g., for exposure to cyanide or organophosphate pesticides.

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.

- Post conspicuously (with duplicates near the telephones) the names, phone numbers, addresses, and procedures for contacting:
  - On-call physicians.
  - Medical specialists.
  - Ambulance services.
  - Medical facility(ies).
  - Emergency, fire, and police services.
  - Poison control hotline.
- Provide maps and directions.
- Make sure at least all managers and all individuals involved in medical response know the way to the nearest emergency medical facility.
- Establish a radio communication system for emergency use.
- Review emergency procedures daily with all site personnel at safety meetings before beginning the work shift.

Table 5-4. Signs and Symptoms of Chemical Exposure and Heat Stress that Indicate Potential Medical Emergencies

TYPE OF HAZARD	SIGNS AND SYMPTOMS
Chemical Hazard	Behavioral changes Breathing difficulties Changes in complexion or skin color Coordination difficulties Coughing Dizziness Drooling Diarrhea Fatigue and/or weakness Irritability Irritation of eyes, nose, respiratory tract, skin, or throat

TYPE OF HAZARD	SIGNS AND SYMPTOMS
Chemical Hazard (cont.)	Headache Light-headedness Nausea Sneezing Sweating Tearing Tightness in the chest
Heat Exhaustion	Clammy skin Confusion Dizziness Fainting Fatigue Heat rash Light-headedness Nausea Profuse sweating Slurred speech Weak pulse
Heat Stroke (may be fatal)	Confusion Convulsions Hot skin, high temperature (yet may feel chilled) Incoherent speech Convulsions Staggering gait Sweating stops (yet residual sweat may be present) Unconsciousness

Non-Emergency Treatment

- Arrangements should be made for non-emergency medical care for hazardous waste site workers who are experiencing health effects resulting from an exposure to hazardous substances. In conjunction with the medical surveillance program, offsite medical care should ensure that any potential job-related symptoms or illnesses are evaluated in the context of the worker's exposure. Offsite medical personnel should also investigate and treat non-job-related illnesses that may put the worker at risk because of task requirements (e.g., a bad cold or flu that might interfere with respirator use). A copy of the worker's medical records should be kept at the site (with provisions for security and confidentiality) and, when appropriate, at a nearby hospital. Treating physicians should have access to these records.

Medical Records

Proper record-keeping is essential at hazardous waste sites because of the nature of the work and risks: employees may work at a large number of geographically separate sites during their careers, and adverse effects of long-term exposure may not become apparent for many years. Records enable subsequent medical care providers to be informed about workers' previous and current exposures.

Occupational Safety and Health Administration (OSHA) regulations mandate that, unless a specific occupational safety and health standard provides a different time period, the employer must:

- Maintain and preserve medical records on exposed workers for 30 years after they leave employment (29 CFR Part 1910.20).
- Make available to workers, their authorized representatives, and authorized OSHA representatives the results of medical testing and full medical records and analyses (29 CFR Part 1910.20).
- Maintain records of occupational injuries and illnesses and post a yearly summary report (29 CFR Part 1904).

Program Review

Regular evaluation of the medical program is important to ensure its effectiveness. Maintenance and review of medical records and test results aid medical personnel, site officers, and the parent company and/or agency managers in assessing the effectiveness of the health and safety program. The Site Safety Officer, medical consultant, and/or management representative should, at least annually:

- Ascertain that each accident or illness was promptly investigated to determine the cause and make necessary changes in health and safety procedures.
- Evaluate the efficacy of specific medical testing in the context of potential site exposures.
- Add or delete medical tests as suggested by current industrial hygiene and environmental data.
- Review potential exposures and Site Safety Plans at all sites to determine if additional testing is required.
- Review emergency treatment procedures and update lists of emergency contacts.

References

1. Proficiency Testing Programs:

Division of Technology Evaluation and
Assistance Laboratory Program Office
Center for Disease Control, Atlanta, GA 30333

College of American Pathologists
7400 N. Skokie Blvd., Skokie, IL 60077
American Association for Bioanalysts
205 W. Levee Street, Brownsville, TX 78520

2. Costello, R.J. 1983. U.S. Environmental Protection Agency Triangle Chemical Site, Bridge City, Texas. NIOSH Health Hazard Evaluations Determination Report, HETA 83-417-1357.

3. ANSI. 1984. American National Standard for Respiratory Protection. ANSI Z88.64984. American National Standards Institute, 1430 Broadway, New York, NY 10018.

4. Gleit, A.; Cohen, A.G.; Chase, K.H.; and J. Toth. 19i5. Summary Report of the Medical Surveillance Program for the Binghamton State Office Building Decontamination Project. Prepared for Versar New York, Inc.

6. Site Characterization

Contents

Introduction

Site characterization provides the information needed to identify site hazards and to select worker protection methods. The more accurate, detailed, and comprehensive the information available about a site, the more the protective measures can be tailored to the actual hazards that workers may encounter.

The person with primary responsibility for site characterization and assessment is the Project Team Leader. In addition, outside experts, such as chemists, health physicists, industrial hygienists, and toxicologists, may be needed to accurately and fully interpret all the available information on site conditions.

Site characterization generally proceeds in three phases:

- Prior to site entry, conduct offsite characterization: gather information away from the site and conduct reconnaissance from the site perimeter.
- Next, conduct onsite surveys. During this phase, restrict site entry to reconnaissance personnel.
- Once the site has been determined safe for commencement of other activities, perform ongoing monitoring to provide a continuous source of information about site conditions.

It is important to recognize that site characterization is a continuous process. At each phase of site characterization, information should be obtained and evaluated to define the hazards that the site may pose. This assessment can then be used to develop a safety and health plan for the next phase of work. In addition to the formal information gathering that takes place during the phases of site characterization described here, all site personnel should be constantly alert for new information about site conditions.

The sections below detail the three phases of site characterization and provide a general guide which should be adapted to meet the specific situation. Within each phase of information gathering, the most appropriate sequence of steps should be determined, particularly if there are time or budget considerations that limit the scope of the work. Wherever possible, all information sources should be pursued.

Offsite Characterization

As much information as possible should be obtained *before* site entry so that the hazards can be evaluated and preliminary controls instituted to protect initial entry personnel. Initial information-gathering missions should focus on identifying all potential or suspected conditions that may pose inhalation hazards that are immediately dangerous to life or health (IDLH)[1] or other conditions that may cause death or serious harm (see Table 6-1).

Offsite information can be obtained by two methods: interview/records research and perimeter reconnaissance.

Table 6-1. Visible Indicators of Potential IDLH and Other Dangerous Conditions

- Large containers or tanks that must be entered.
- Enclosed spaces such as buildings or trenches that must be entered.
- Potentially explosive or flammable situations (indicated by bulging drums, effervescence, gas generation, or instrument readings).
- Extremely hazardous materials (such as cyanide, phosgene, or radiation sources).
- Visible vapor clouds.
- Areas where biological indicators (such as dead animals or vegetation) are located.

Interview/Records Research

As much data as possible should be collected before any personnel go on site. Where possible, the following information should be obtained:

- Exact location of the site
- Detailed description of the activity that occurred at the site.
- Duration of the activity.
- Meteorologic data, e.g., current weather and forecast, prevailing wind direction, precipitation levels, temperature profiles.
- Terrain, e.g., historical and current site maps, site photographs, aerial photographs, U.S. Geological Survey topographic quadrangle maps, land use maps, and land cover maps.
- Geologic and hydrologic data.
- Habitation-population centers, population at risk.
- Accessibility by air and roads.
- Pathways of dispersion.
- Present status of response and who has responded.
- Hazardous substances involved and their chemical and physical properties. Information sources Include:

[1] IDLH conditions refer to inhalation hazards (see section on *IDLH Concentrations* later in this chapter).

  - Company records, receipts, logbooks, or ledgers.
  - Records from state and federal pollution control regulatory and enforcement agencies, state Attorney General's office, state occupational safety and health agencies, state Fire Marshal's office.
  - Waste storage inventories and manifests or shipping papers.
  - Interviews with personnel and their families (all interview information should be verified). Generator and transporter records.
  - Water department and sewage district records. Interviews with nearby residents (note possible site-related medical problems and verify all information from interviews).
  - Local fire and police department records. Court records.
  - Utility company records.
  - Media reports (verify all information from the media).
- Previous surveying (including soil, ground-penetrating radar, and magnetometer surveys), sampling, and monitoring data.

Perimeter Reconnaissance

At a site in which the hazards are largely unknown or there is no need to go on site immediately, visual observations should be made, atmospheric concentrations of airborne pollutants at the site perimeter should be monitored (see Chapter 7, *Air Monitoring*), and samples should be collected near the site. While these data are not definitive indicators of onsite conditions, they can assist in the preliminary evaluation. Perimeter reconnaissance of a site should involve the following actions:

- Develop a preliminary site map, with the locations of buildings, containers, impoundments, pits, ponds, and tanks.
- Review historical and current aerial photographs. Note:
- Disappearance of natural depressions, quarries, or pits.
- Variation in reforestation of disturbed areas.
- Mounding or uplift in disturbed areas or paved surfaces, or modifications in grade.
- Changes in vegetation around buildings.
- Changes in traffic patterns at the site.
- Note any labels, markings, or placards on containers or vehicles.
- Note the amount of deterioration or damage of containers or vehicles.
- Note any biologic indicators, such as dead animals or plants.
- Note any unusual conditions, such as clouds, discolored liquids, oil slicks, vapors, or other suspicious substances.
- Monitor the ambient air at the site perimeter (see Chapter 7, *Air Monitoring*) for:
  - Toxic substances.
  - Combustible and flammable gases or vapors.
  - Oxygen deficiency.
  - Ionizing radiation.
  - Specific materials, if known.
- Note any unusual odors.
- Collect and analyze offsite samples (see reference III for methods) including:
  - Soil.
  - Drinking water.
  - Ground water.
  - Site run-off.
  - Surface water.

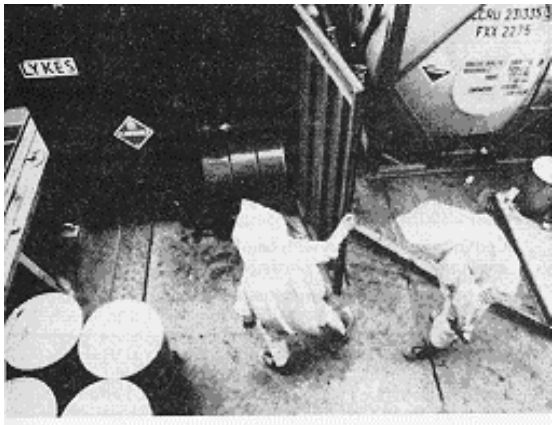
Protection of Entry Personnel

The information from interview/records research and perimeter reconnaissance is used as the basis for selecting the protective equipment for the initial site survey. In addition, the proposed work to be accomplished must be considered. For example, if the purpose of the survey is to inspect onsite conditions, count containers, measure the ambient air for "hot spots" (i.e., areas with high concentrations of toxic chemicals), and generally become familiar with the site, the level of protection may be less stringent than if containers are to be opened and samples taken. (Chapter 8, *Personal Protective Equipment*, provides more detail on the selection of protective items.)

The ensemble of clothing and equipment referred to as Level B protection is generally the minimum level recommended for an initial entry until the site hazards have been further identified and the most appropriate protective clothing and equipment chosen. Level B equipment is described in Table 8-7, Chapter 8.

Onsite Survey

The purpose of an onsite survey is to verify and supplement information from the offsite characterization. Prior to going on site, the offsite characterization should be used to develop a Site Safety Plan for site entry that addresses the work to be accomplished and prescribes the procedures to protect the health and safety of the entry team. Priorities should be established for hazard assessment and site activities after careful evaluation of probable conditions. Because team members may be entering a largely unknown environment, caution and conservative actions are appropriate. The composition of the entry team depends on the site characteristics but should always consist of at least four persons: two workers who will enter the site and two outside support persons, suited in personal protective equipment and prepared to enter the site in cage of emergency. Upon entering the site, entry personnel should:



As part of site characterization, workers suited in Level A protective ensembles work in pairs when investigating confined spaces.

- Monitor the air for IDLH and other conditions that may cause death or serious harm (combustible or explosive atmospheres, oxygen deficiency, toxic substances). Chapter 7 provides detailed information on air monitoring.
- Monitor for ionizing radiation. Survey for gamma and beta radiation with a Geiger-·Mueller detection tube or a gamma scintillation tube; if alpha radiation is expected, use a proportional counter.
- Visually observe for signs of actual or potential IDLH or other dangerous conditions (see Table 6-1).

Any indication of IDLH hazards or other dangerous conditions should be regarded as a sign to proceed with care and deliberation. Extreme caution should be exercised in continuing the site survey when such hazards are indicated. Table 6-2 provides some basic guidelines for decision-

making. If IDLH or other dangerous conditions are not present, or if proper precautions can be taken, continue the survey:

- Conduct further air monitoring as necessary (see Chapter 7).
- Note the types of containers, impoundments, or other storage systems:
  - Paper or wood packages.
  - Metal or plastic barrels or drums.
  - Underground tanks.
  - Aboveground tanks.
  - Compressed gas cylinders.
  - Pits, ponds, or lagoons.
  - Other.
- Note the condition of waste containers and storage systems:
  - Sound (undamaged).
  - Visibly rusted or corroded.
  - Leaking.
  - Bulging.
  - Types and quantities of material in containers.
  - Labels on containers indicating corrosive explosive, flammable, radioactive or toxic materials.
- Note the physical condition of the materials:
  - Gas, liquid, or solid.
  - Color and turbidity.
  - Behavior, e.g., corroding, foaming or vaporizing.
  - Conditions conducive to splash or contact.
- Identify natural wind barriers:
  - Buildings.
  - Hills.
  - Tanks.
- Determine the potential pathways of dispersion:
  - Air.
  - Biologic routes, such as animals and food chains.
  - Ground water.
  - Land surface.
  - Surface water.
- If necessary, use one or more of the following remote sensing or subsurface investigative methods to locate buried wastes or contaminant plumes:
  - Electromagnetic resistivity.
  - Seismic refraction.
  - Magnetometry.
  - Metal detection.
  - Ground-penetrating radar.
- Note any indicators of potential exposure to hazardous substances:
  - Dead fish, animals or vegetation.

- Dust or spray in the air.
- Fissures or cracks in solid surfaces that expose deep waste layers.
- Pools of liquid.
- Foams or oils on liquid surfaces.
- Gas generation or effervescence.
- Deteriorating containers.
- Cleared land areas or possible landfilled areas.

- Note any safety hazards. Consider:
  - Conditions of site structures.
  - Obstacles to entry and exit.
  - Terrain homogeneity.
  - Terrain stability.
  - Stability of stacked material.
- Identify any reactive, incompatible, flammable, or highly corrosive wastes.
- Note land features.
- Note the presence of any potential naturally occurring skin irritants or dermatitis-inducing agents, for example:
  - Poison ivy.
  - Poison oak.
  - Poison sumac.
- Note any tags, labels, markings, or other identifying indicators.
- Collect samples [1]:
  - Air (see Chapter 7, *Air Monitoring*).
  - Drainage ditches.
  - Soil (surface and subsurface).
  - Standing pools of liquids.
  - Storage containers.
  - Streams and ponds.
  - Ground water (upgradient, beneath site, downgradient).
- Sample for or otherwise identify:
  - Biologic or pathologic hazards.
  - Radiologic hazards.

Table 6-2. Guidelines for Some Atmospheric Hazards[a]

HAZARD[b]	MONITORING EQUIPMENT[c]	MEASURED LEVEL	ACTION
Explosive atmosphere	Combustible gas indicator	<10% LEL[d] 10%-25% LEL >25% LEL	Continue investigation. Continue onsite monitoring with extreme caution as higher levels are encountered. Explosion hazard. Withdraw from area immediately.
Oxygen	Oxygen concentration meter	<19.5% 19.5%-25% >25%	Monitor wearing self-contained breathing apparatus. NOTE: Combustible gas readings are not valid in atmospheres with <19.5% oxygen. Continue investigation with caution. Deviation

HAZARD[b]	MONITORING EQUIPMENT[c]	MEASURED LEVEL	ACTION
Oxygen (cont.)			from normal level may be due to the presence of other substances. Fire hazard potential. Discontinue investigation. Consult a fire safety specialist.
Radiation	Radiation survey equipment	≤2 mrem/hr[e,f] >2 mrem/hr	Radiation above background levels (normally 0.01-0.02 mrem/hr)[g] signifies the possible presence of radiation sources. Continue investigation with caution. Perform thorough monitoring. Consult with a health physicist. Potential radiation hazard. Evacuate site. Continue investigation only upon the advice of a health physicist.
Inorganic and organic gases and vapors	Colorimetric tubes Chemical-specific instruments, including halide meter, hydrogen sulfide detector, carbon monoxide monitor, and mercury meter	Depends on chemical	Consult standard reference manuals for air concentration/toxicity data. Action level depends on PEL/REL/TLV.[h]
Organic gases and vapors	Portable photoionizer Organic vapor analyzer (1) Operated in gas chromatography (GC) mode (2) Operated in survey mode	Depends on chemical	Consult standard reference manuals for air concentration/toxicity data. Action level depends on PEL/REL/TLV.[h]

[a]Based on *Standard Operating Guides*. U.S. EPA. December, 1984.
[b]These are general classes of hazards. Not all components of these classes can be measured.
[c]Consult manufacturers' literature for use limitations associated with the specific equipment and for the specific substances the equipment can detect. See Tables 7-1 and 7-2 for more complete descriptions.
[d]LEL = lower explosive limit.
[e]mrem/hr = milliroentgen equivalent in man per hour
[f]Source: U.S. Nuclear Regulatory Commission Rules and Regulations, 10 CFR Chapter 1, Part 20.105.
[g]Source: Sax, I.N. 1979. Dangerous Properties of Industrial Materials. Fifth Edition. p. 167. Van Nostrand Reinhold Company, New York.
[h] PEL = OSHA permissible exposure limit.
REL = NIOSH recommended exposure limit.
TLV = threshold limit value.

See Table 6-4.

Information Documentation

Proper documentation and document control are important for ensuring accurate communication; ensuring the quality of the data collected; providing the rationale for safety decisions; and substantiating possible legal actions. Documentation can be accomplished by recording information pertinent to field activities, sample analysis, and site conditions in one of several ways, including:

- Logbooks.
- Field data records.
- Graphs.
- Photographs.
- Sample labels.
- Chain-of-custody forms.

- Analytical records.

These documents should be controlled to ensure that they are all accounted for when the project is completed. The task of document control should be assigned to one individual on the project team and should include the following responsibilities:

- Numbering each document (including sample labels) with a unique number.
- Listing each document in a document inventory.
- Recording the whereabouts of each document in a separate document register so that any document can be readily located. In particular, the name and location of site personnel that have documents in their possession should be recorded.
- Collecting all documents at the end of each work period.
- Making sure that all document entries are made in waterproof ink.
- Filing all documents in a central file at the completion of the site response.

Field personnel should record all onsite activities and observations in a field logbook-a bound book with consecutively numbered pages. Entries should be made during or just after completing a task to ensure thoroughness and accuracy. Table 6-3 shows the level of detail that should be recorded during sampling.

Photographs can be an accurate, objective addition to a field worker's written observations. For each photograph taken, the following information should be recorded in the field logbook:

- Date, time, and name of site.
- Name of the photographer.
- Location of the subject within the site.
- General compass direction of the orientation of the photograph.
- General description of the subject.
- Sequential number of the photograph and the film roll number.
- Camera, lens, and film type used for photography.

Table 6-3. Example of Field Logbook Entries to Describe Sampling

- Date and time of entry.
- Purpose of sampling.
- Name, address, and affiliation of personnel performing sampling.
- Name and address of the material's producer, if known.
- Type of material, e.g., sludge or wastewater.
- Description of material container.
- Description of sample.
- Chemical components and concentrations, if known.
- Number and size of samples taken.
- Description and location of the sampling point.
- Date and time of sample collection.
- Difficulties experienced in obtaining sample (e.g., is it representative of the bulk material?).
- Visual references, such as maps or photographs of the sampling site.
- Field observations, such as weather conditions during sampling periods.
- Field measurements of the materials, e.g., explosiveness, flammability, or Ph.
- Whether chain-of-custody forms have been filled out for the samples.

Serially numbered sample labels or tags should be assigned to sampling team personnel and recorded in the field logbook. Lost, voided, or damaged labels should be noted in the logbook. Labels should be firmly affixed to the sample containers using either gummed labels or tags attached by string or wire. Information should be recorded on the tag in waterproof ink and should include items such as:

- The unique sample log number.
- Date and time that the sample was collected.
- Source of the sample, e.g., name, location, and type of sample.
- Preservative used.
- Analysis required.
- Name of collector.
- Pertinent field data.

In addition to supporting litigation, written records of sample collection, transfer, storage, analysis, and destruction help ensure the proper interpretation of analytical test results. Information describing the chain of custody should be recorded on a form that accompanies the sample from collection to destruction.

Sample jars are labeled prior to sampling as part of site documentation procedures.

Hazard Assessment

Once the presence and concentrations of specific chemicals or classes of chemicals have been established, the hazards associated with these chemicals must be determined. This is done by referring to standard reference sources for data and guidelines on permissible levels of exposure, flammability, etc. Some key guidelines are listed in Table 6-4 and are described below.

Threshold Limit Value (TLV)®

TLVs can be used as a guideline for determining the appropriate level of worker protection. These values have been derived for many substances and can be found in *Threshold Limit Values for Chemical Substances and Physical Agents*, which is published annually by the American Conference of Governmental Industrial Hygienists (ACGIH) 121. The ACGIH defines three categories of TLVs: time-eighted average (TWA); short-term exposure limit (STEL); and ceiling (C).All three categories may be useful in selecting levels of protection at a hazardous waste site. Refer to the *Threshold Limit Values for Chemical Substances and Physical Agents* [2] for additional details.

Permissible Exposure Limit (PEL)

Permissible exposure limits are enforceable standards promulgated by OSHA. In many cases they are derived from TLVs published in 1968. The PEL for a substance is the 8-hour time-weighted average or ceiling concentration above which workers may not be exposed. Although

personal protective equipment may not be required for exposures below the PEL, its use may be advisable where there is a potential for overexposure. See the tables and substance-specific standards in 29 CFR Part 1910, Subpart Z, for additional details.

Recommended Exposure Limit (REL)

A NIOSH recommended exposure limit (REL) is the workplace exposure concentration recommended by NIOSH for promulgation by OSHA as a PEL, but is not enforceable as is the OSHA PEL. In some cases, NIOSH has described time-weighted average concentrations in terms of 10-hour, rather than 8-hour, averages.

Table 6-4. Guidelines for Assessing Chemical and Physical Hazards

HAZARD	GUIDELINE		EXPLANATION	SOURCES FOR VALUES[a]
Inhalation of airborne contaminants	TLV	Threshold Limit Value	One of three categories of chemical exposure levels, defined as follows:	
	TLV-TWA	Threshold Limit Value-Time-Weighted Average	The time-weighted average concentration for a normal 8-hour workday and a 40-hour work week, to which nearly all workers may be repeatedly exposed without adverse effect. Should be used as an exposure guide rather than an absolute threshold.	ACGIH
	TLV-STEL	Threshold Limit Value-Short-Term Exposure Limit	A 15-minute time-weighted average exposure that should not be exceeded at any time during the work day.	ACGIH
	TLV-C	Threshold Limit Value-Ceiling	The concentration that should not be exceeded even instantaneously.	ACGIH
	PEL	Permissible Exposure Limit	Time-weighted average and ceiling concentrations similar to (and in many cases derived from) the threshold limit values published in 1968.	OSHA
	REL	Recommended Exposure Limit	Time-weighted averages and ceiling concentrations based on NIOSH evaluations.	NIOSH
	IDLH	Immediately Dangerous to Life or Health	The maximum level from which a worker could escape without any escape-impairing symptoms or any irreversible health effects.	NIOSH
Dermal absorption of chemicals through airborne or direct contact Dermal irritation	Designation "skin"		The designation "skin" in the ACGIH, OSHA, and NIOSH references[a] indicates that a substance may be readily absorbed through the intact skin; however, it is not a threshold for safe exposure. Direct contact with a substance designated "skin" should be avoided. Many substances irritate skin. Consult standard references	ACGIH/ OSHA/ NIOSH
Carcinogens	TLV	Threshold Limit Value	Some carcinogens have an assigned TLV.	ACGIH
	PEL	Permissible Exposure Limit	OSHA has individual standards for some specific carcinogens.	OSHA
	REL	Recommended Exposure Limit	NIOSH makes recommendations regarding exposures to carcinogens.	NIOSH

HAZARD	GUIDELINE		EXPLANATION	SOURCES FOR VALUES[a]
Noise	TLV	Threshold Limit Value	Sound pressure levels and durations of exposure that represent conditions to which it is believed that nearly all workers may be repeatedly exposed without an adverse effect on their ability to hear and understand normal speech.	ACGIH
	PEL	Permissible Exposure Limit	.Limits for acceptable noise exposure.	OSHA
	REL	Recommended Exposure Limit	Limits for acceptable noise exposure.	NIOSH
Ionizing Radiation	Maximum permissible body burden and maximum permissible concentrations of radionuclides in air and in water.			NCRP
	PEL	Permissible Exposure Limit	Dose in rems per calendar quarter.	OSHA
Explosion	LEL	Lower Explosive Limit	The minimum concentration of vapor in air below which propagation of a flame will not occur in the presence of an ignition source.	NFPA
	UEL	Upper Explosive Limit	The maximum concentration of a vapor in air above which propagation of a flame will not occur in the presence of an ignition source.	NFPA
Fire	Flash Point		The lowest temperature at which the vapor of a combustible liquid can be made to ignite momentarily in air.	NFPA

[a]Sources:
ACGIH. 1984-85. Threshold Limit Values for Chemical Substances and Physical Agents in the Workplace Environment and Biological Exposure Indices with Intended Changes for 1985-86. American Conference of Governmental Industrial Hygienists, Cincinnati, Ohio.
NIOSH. Centers for Disease Control. 1983. NIOSH Recommendations for Occupational Health Standards. Morbidity and Mortality Weekly Report Supplement. Vol. 32, No. 1S, October 7, 1983.
NIOSH. 1985. Pocket Guide to Chemical Hazards. National Institute for Occupational Safety and Health, Cincinnati, Ohio.
NCRP. Basic Radiation Protection Criteria. NCRP Report No. 39. National Council on Radiation Protection and Measurements, Washington, D.C.
NCRP. Maximum Permissible Body Burdens and Maximum Permissible Concentrations of Radionuclides in Air and Water for Occupational Exposure. NCRP Report No. 22. National Council on Radiation Protection and Measurements, Washington, D.C.
NFPA. 1985. Fire Protection Guide on Hazardous Materials. Eighth Edition. National Fire Protection Association, Boston, Massachusetts.
OSHA. 29 CFR Part 1910. (OSHA standards are legally binding.)
[b]Other sources have slightly different definitions of IDLH (see IDLH Concentrations in this chapter).

IDLH Concentrations

IDLH exposure concentrations have been established by the NIOSH/OSHA Standards Completion Program (SCP) as a guideline for selecting respirators for some chemicals. The definition of IDLH varies depending on the source. For example, the Mine Safety and Health Administration Standard (30 CFR Part 11.3(t)) defines IDLH conditions as those that pose an immediate threat to life or health or that pose an immediate threat of severe exposure to contaminants such as radioactive materials that are likely to have adverse cumulative or delayed effects on health. The NIOSH *Pocket Guide to Chemical Hazards* [3] defines IDLH concentration as the "... maximum level from which one could escape within 30 minutes without any escape-impairing symptoms or any irreversible health effects....." The American National Standards Institute, Inc. (ANSI) defines IDLH as "….any atmosphere that poses an immediate hazard to life

or produces immediate irreversible debilitating effects on health ..." [4]. Regardless of their exact definition, all IDLH values indicate those concentrations of toxic substances from which escape is possible without irreversible harm should a worker's respiratory protective equipment fail. At hazardous waste sites, IDLH concentrations should be assumed to represent concentrations above which only workers wearing respirators that provide the maximum protection (i.e., a positive-pressure, full-facepiece, self-contained breathing apparatus [SCBA] or a combination positive-pressure, full-facepiece, supplied-air respirator with positive-pressure SCBA [see Chapter 8) are permitted. Specific IDLH values for many substances can be found in the NIOSH *Pocket Guide to Chemical Hazards* [3].

Potential Skin Absorption and Irritation

Information on skin absorption is provided in the ACGIH publication, *Threshold Limit Values for Chemical Substances and Physical Agents* [2] and in OSHA standard 29 CFR Part 1910.1000 and other standard references. These documents identify substances that can be readily absorbed through the skin, mucous membranes, and/or eyes by either airborne exposure or direct contact with a liquid. This information, like most available information on skin absorption is qualitative. It indicates whether, but not to what extent, a substance may pose a dermal hazard. Thus decisions made concerning skin hazards are necessarily judgmental.

In addition, many chemicals, although not absorbed through the skin, may cause skin irritation at the point of contact. Signs of skin irritation range from redness, swelling, or itching to burns that destroy skin tissue. Standard references can be used to determine whether a chemical may act as an irritant.

Potential Eye Irritation

Quantitative data on eye irritation are not always available. Where a review of the literature indicates that a substance causes eye irritation, but no threshold is specified, have a competent health professional evaluate the data to determine the level of personal protection needed for onsite workers.

Explosion and Flammability Ranges

The lower explosive limit (LEL) or lower flammable limit (LFL) of a substance is the minimum concentration of gas or vapor in air below which the substance will not burn when exposed to a source of ignition. This concentration is usually expressed in percent by volume. Below this concentration, the mixture is too "lean" to burn or explode.

The upper explosive limit (UEL) or upper flammable limit (UFL) of a substance is the maximum concentration of gas or vapor above which the substance will not burn when exposed to a source of ignition. Above this concentration, the mixture is too "rich" to burn or explode.

The flammable range is the range of concentrations between the LFL and UFL where the gas-air mixture will support combustion'.

The flashpoint of a substance is the minimum temperature at which it gives off sufficient vapor to form an ignitable mixture with the air just above the surface of the substance. Ignition of a substance at the flashpoint is not continuous.

The ignition temperature or autoignition temperature is the minimum temperature required to initiate or cause self-sustained combustion without an ignition source.

When evaluating the fire or explosion potential at a hazardous waste site, all equipment used should be intrinsically safe or explosion-proof. Where flammable or explosive atmospheres are detected, ventilation may dilute the mixture to below the LEL/LFL. However, ventilation is generally not recommended if concentrations exceed the UFL/UEL, since the mixture will pass through the flammable/explosive range as it is diluted. Note that combustible gas indicator readings may not be accurate when oxygen concentrations are less than 19.5 percent.

Hazardous Substance Information Form

Information on the chemical, physical, and toxicologic properties of each compound known or expected to occur on site should be recorded on a Hazardous Substance Information Form (see Appendix C). Response personnel will then have the necessary health and safety information in one place, and new personnel can be quickly briefed. As many reference sources as possible should be used to fill out the sheets because the information may vary from one source to another. Material Safety Date Sheets provided by chemical manufacturers are one source for this information.

Monitoring

Because site activities and weather conditions change, an ongoing air monitoring program should be implemented after characterization has determined that the site is safe for the commencement of operations.

The ongoing monitoring of atmospheric chemical hazards should be conducted using a combination of stationary sampling equipment, personnel monitoring devices, and periodic area monitoring with direct-reading instruments (see Chapter 7, *Air Monitoring*).

Data obtained during offsite and onsite surveys can be used to develop a plan that details the procedures to be used for monitoring ambient conditions during cleanup operations. Where necessary, routes of exposure other than inhalation should be monitored. For example, skin swipe tests may be used to determine the effectiveness of personal protective clothing (see Chapter 10, *Decontamination*). Depending on the physical properties and toxicity of the onsite materials, community exposures resulting from hazardous waste site operations may need to be assessed [5].

Monitoring also includes continual evaluation of any changes in site conditions or work activities that could affect worker safety. When a significant change occurs, the hazards should be reassessed. Some indicators of the need for reassessment are:

- Commencement of a new work phase, such as the start of drum sampling.
- Change in job tasks during a work phase.
- Change of season.
- Change in weather.
- Change in ambient levels of contaminants.

References

1. U.S. EPA. 1984. Characterization of Hazardous Waste Sites-A Methods Manual: Volume II. Available Sampling Methods. Second edition. EPA 600/4-84-076.

2. ACGIH. 1984-85. Threshold Limit Values for Chemical Substances and Physical Agents in the Workplace Environment and Biological Exposure Indices with Intended Changes for 1985-86. American Conference of Governmental Industrial Hygienists, Cincinnati, OH.

3. NIOSH. 1985. Pocket Guide to Chemical Hazards. National Institute for Occupational Safety and Health, Cincinnati, OH.

4. ANSI. 1980. Practices for Respiratory Protection. ANSI Z88.2-1980. American National Standards Institute, 1430 Broadway, New York, NY 10018.

5. U.S. Department of Health and Human Services. 1984. A System for Prevention, Assessment and Control of Exposures and Health Effects from Hazardous Sites (S.P.A.C.E. for Health), U.S. Department of Health and Human Services, Public Health Service, Center for Disease Control, Atlanta, GA.